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LEMBECK LAKE DAM
JEFFERSON COUNTY, MISSOURI
MO. 30369

PHASE I INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM

United States Army
Corps of Engineers
Serving the Army
Serving the Nation

St. Louis District

PREPARED BY: U. S. ARMY ENGINEER DISTRICT, ST. LOUIS

FOR: STATE OF MISSOURI

JULY 1981

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20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

This report was prepared under the National Program of Inspection of Non-Federal Dams. This report assesses the general condition of the dam with respect to safety, based on available data and on visual inspection, to determine if the dam poses hazards to human life or property.

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DEPARTMENT OF THE ARMY
ST. LOUIS DISTRICT, CORPS OF ENGINEERS
210 TUCKER BOULEVARD, NORTH
ST. LOUIS, MISSOURI 63101

REPLY TO
ATTENTION OF

SUBJECT: Lembeck Lake Dam (Mo. 30369) Phase I Inspection Report

This report presents the results of field inspection and evaluation of the Lembeck Lake Dam (Mo. 30369).

It was prepared under the National Program of Inspection of Non-Federal Dams.

This dam has been classified as unsafe, non-emergency by the St. Louis District as a result of the application of the following criteria:

a. The spillway will not pass 50 percent of the Probable Maximum Flood without overtopping the dam.

b. *Overtopping of the dam could result in failure of the dam.*

c. Dam failure significantly increases the hazard to loss of life downstream.

SUBMITTED BY: SIGNED — 21 JUL 1981
Chief, Engineering Division — Date

APPROVED BY: SIGNED — 23 JUL 1981
Colonel, CE, Commanding — Date

LEMBECK LAKE DAM
JEFFERSON COUNTY, MISSOURI

MISSOURI INVENTORY NO. 30369

PHASE I INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM

PREPARED BY
PRC CONSOER TOWNSEND, INC.
ST. LOUIS, MISSOURI
AND
PRC ENGINEERING CONSULTANTS, INC.
ENGLEWOOD, COLORADO
A JOINT VENTURE

UNDER DIRECTION OF
ST. LOUIS DISTRICT, CORPS OF ENGINEERS
FOR
GOVERNOR OF MISSOURI

JULY 1981

PHASE I INSPECTION REPORT

NATIONAL DAM SAFETY PROGRAM

Name of Dam:	Lembeck Lake Dam, Missouri Inventory No. 30369
State Located:	Missouri
County Located:	Jefferson
Stream:	Whitehead Creek
Date of Inspection:	March 5, 1981

Assessment of General Condition

Lembeck Lake Dam was inspected by the engineering firms of PRC Consoer Townsend, Inc. of St. Louis, Missouri, and PRC Engineering Consultants, Inc. of Englewood, Colorado, (A Joint Venture) in accordance with the U. S. Army Corps of Engineers "Recommended Guidelines for Safety Inspection of Dams" and additional guidelines furnished by the St. Louis District of the Corps of Engineers. Based upon the criteria in the guidelines, the dam is in the high hazard potential classification, which means that loss of life and appreciable property loss could occur in the event of failure of the dam. Located within the estimated damage zone of less than three miles downstream of the dam are 24 dwellings, four buildings, one railroad embankment, one state highway (Highway 110) and one railroad terminal, which may be subjected to flooding, with possible damage and/or destruction, and possible loss of life. Lembeck Lake Dam is in the small size classification since it is 26.4 feet high and has a maximum reservoir impoundment of 208 acre-feet.

The inspection and evaulation indicates that the spillway of Lembeck Lake Dam does not meet the criteria set forth in the guidelines for a dam having the above size and hazard potential. Lembeck Lake Dam being a small size dam with a high hazard potential is required by the guidelines to pass from one-half of the Probable Maximum Flood to the Probable Maximum Flood without overtopping the dam. Considering the possibility of loss of life and the destruction of property downstream of the dam, the PMF is considered the appropriate spillway design flood for Lembeck Lake Dam. The Probable Maximum Flood is defined as the flood discharge that may be expected from the most severe combination of critical meteorological and hydrologic conditions that are reasonably possible in the region. It was determined that the reservoir/spillway system can accommodate approximately 13 percent of the Probable Maximum Flood without overtopping the dam. The evaluation also indicates that the reservoir/spillway system can accommodate the ten-percent chance flood (10-year flood) without overtopping the dam, but cannot accommodate the one-percent chance flood (100-year flood) without overtopping the dam.

The overall condition of the dam and appurtenant structures appears to be poor, due to several deficiencies noted by the inspection team. The deficiencies included: the failure of the downstream apron of the spillway weir; the erosion in the spillway discharge channel; the instability of the low-level outlet gate stem support pedestals; the erosion of the downstream embankment toe caused by the low-level outlet discharge and the undermining of the headwall of the sluice gate; the obstruction of the low-level outlet discharge channel; the erosion of the upstream slope due to wave action and along the right abutment/embankment contact; the large vegetation ranging from brush to large trees observed on the upstream and downstream slopes; the driftwood and debris on the upstream slope; a need for periodical maintenance of the grass cover on the embankment slopes and a lack of a maintenance schedule; and there also exists a need for periodic inspections by a qualified engineer. The lack of seepage and stability analyses on record is also a deficiency that should be corrected.

It is recommended that the owner take action to correct or control the deficiencies described above.

Walter G. Shifrin, P.E.

STATE OF MISSOURI
WALTER
G. SHIFRIN
NUMBER
E-8834
REGISTERED PROFESSIONAL ENGINEER

Overview of Lembeck Lake Dam

NATIONAL DAM SAFETY PROGRAM

LEMBECK LAKE DAM, I.D. No. 30369

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NATIONAL DAM SAFETY PROGRAM

LEMBECK LAKE DAM, Missouri Inv. No. 30369

SECTION 1: PROJECT INFORMATION

1.1 General

a. Authority

The Dam Inspection Act, Public Law 92-367 of August, 1972, authorizes the Secretary of the Army, through the Corps of Engineers, to initiate a national program of dam inspections. Inspection for Lembeck Lake Dam was carried out under Contract DACW 43-81-C-0063 between the Department of the Army, St. Louis District, Corps of Engineers, and the engineering firms of PRC Consoer Townsend, Inc. of St. Louis, Missouri, and PRC Engineering Consultants, Inc. of Englewood, Colorado, (A Joint Venture).

b. Purpose of Inspection

The visual inspection of Lembeck Lake Dam was made on March 5, 1981. The purpose of the inspection was to make a general assessment as to the structural integrity and operational adequacy of the dam embankment and its appurtenant structures.

c. Scope of Report

This report summarizes available pertinent data relating to the project, presents a summary of visual observations made during the field inspection, presents an assessment of hydrologic and hydraulic conditions at the site and of structural adequacy of

the various project features, and assesses the general condition of the dam with respect to safety.

Subsurface investigations, laboratory testing and detailed analyses were not within the scope of this study. No warranty as to the absolute safety of the project features is implied by the conclusions presented in this report.

It should be noted that in this report reference to left or right abutments is viewed as looking downstream. Where left abutment or left side of the dam is used in this report, this also refers to the north abutment or side, and right to the south abutment or side.

d. Evaluation Criteria

The inspection and evaluation of the dam is performed in accordance with the U.S. Army Corps of Engineers "Recommended Guidelines for Safety Inspection of Dams" and additional guidelines furnished by the St. Louis District office of the Corps of Engineers for Phase I Dam Inspection.

1.2 Description of the Project

a. Description of Dam and Appurtenances

The following description is based upon observations and measurements made during the visual inspection and conversations with Mr. John Lembeck, the son of the previous owner of the dam. No design or "as-built" drawings for the dam or appurtenant structures were available.

The dam is a homogeneous, rolled, earthfill structure with a core trench excavated to sound bedrock, according to Mr. Lembeck. The alignment of the dam is straight between earth abutments. A plan and elevation of the dam are shown on Plate 4 and

Photos 1 through 3 show views of the dam. The top of the dam has a length of 590 feet between the right abutment and the spillway, and an assumed minimum elevation of 550.0 feet above mean sea level (M.S.L.) at a point 200 feet from the right abutment. From the spillway, the top of dam was surveyed to be level to a point 90 feet to the right. For the next 300 feet of the dam, to the location of the minimum top of dam elevation, the top of dam slopes downward with a drop in elevation of 1.1 feet. The top of dam, for the last 200 feet, sloped upward to the abutment contact with a rise of 1.1 feet in elevation. The embankment has a top width of 17 feet and a maximum structural height of 26.4 feet. The embankment slopes were measured to be 1 vertical to 2.5 horizontal (1V to 2.5H) and 1V to 3.5H on the downstream and the upstream faces, respectively.

There is only one spillway at this damsite which consists of a channel cut into the weathered bedrock of the left abutment. The control section of the spillway is a broad-crested weir 13 feet wide and 80 feet long that also serves as an access road which proceeds across the top of the dam (see Photos 5 and 6). The weir has a parabolic shape with the minimum crest elevation of 544.9 feet above M.S.L., which is the normal reservoir elevation. The weir is constructed of a three to four inch thick, nonreinforced, concrete slab placed on top of riprap. The sloping upstream and downstream aprons of the weir are also paved with concrete. The upstream apron is mostly covered by reservoir sediment. The downstream apron slopes downward from the weir crest to the spillway discharge channel with a three feet drop in elevation. Downstream of the weir the spillway discharge channel bottom is lined with weathered bedrock (see Photo 7). The left side slope of the channel is tree and brush covered. Remnants of a concrete retaining wall and grass and riprap covered embankment material comprise the right side slope of the channel (see Photo 9). The channel bottom is a series of ledges and chutes in the bedrock as the spillway proceeds downstream of the dam embankment and curves toward the downstream channel. Downstream of the dam embankment, the channel is aligned roughly parallel to the axis of the dam and is adjacent to a railroad

embankment (see Photo 10). Here the channel bottom is lined with bedrock, rubble and small trees and the side slopes are bare earth. The discharge channel joins the downstream channel at the entrance of a masonry arch conduit, which passes under the railroad embankment about 100 feet downstream of the toe of the dam.

A low-level outlet is provided for this dam, which consists of a sluice gate inlet and a 24-inch diameter corrugated metal pipe (CMP) outlet (see Photos 14 and 16). The gate is located on the upstream slope 13.5 feet below the top of dam and 220 feet to the left of the right abutment. The gate is manually operated from the top of dam and is inclined at the same slope as the upstream embankment face. The gate stem and gate stem encasement pipe are supported by five concrete pedestals placed on the embankment between the gate and the top of the dam (see Photo 12). The gate is 25 inches square and covers an opening of unknown size in a concrete headwall (see Photo 13). The opening in the headwall leads to the CMP outlet in an unknown manner. The CMP travels through the dam and outlets above the downstream toe of the dam and into an earth-lined stilling basin. An earth-lined outlet channel carries flow from the stilling basin to the downstream channel.

b. Location

Lembeck Lake Dam is located in Jefferson County in the State of Missouri on Whitehead Creek. The location of the dam on the 7.5 minute series of the U.S. Geological Survey maps is found in the northeast quadrant of Section 10 of Township 39 North, Range 4 East, of the Vineland, Missouri Quadrangle Sheet (Advance Print, see Plate 2). The dam axis is situated approximately parallel to and 100 feet upstream of a Missouri Pacific Railroad track and embankment.

c. Size Classification

The reservoir impoundment of Lembeck Lake Dam is less than 1,000 acre-feet but more than 50 acre-feet, which would classify it as a "small" size dam. The maximum height of the dam is less than 40 feet and greater than 25 feet, which also classifies it as a "small" size dam. The size classification is determined by either the storage or height, whichever gives the larger size category. Therefore, the size classification is determined to fall within the "small" category, according to the "Recommended Guidelines for Safety Inspection of Dams" by the U.S. Department of the Army, Office of the Chief Engineer.

d. Hazard Classification

The dam has been classified as having a "high" hazard potential in the National Inventory of Dams, on the basis that in the event of failure of the dam or its appurtenances, excessive damage could occur to downstream property, together with the possibility of the loss of life. From a visual inspection of the downstream area, our findings concur with this classification. Located within the estimated damage zone, which extends less than three miles downstream of the dam, are at least 24 dwellings, four buildings, one railroad embankment, one state highway (Highway 110) and one railroad terminal (see Photo 18).

The railroad embankment downstream of the dam was surveyed to be 10.5 feet higher than the minimum top of dam. Because of this, the railroad embankment might provide some additional safety to the downstream hazard zone if the dam were to fail. However, the railroad embankment would be overtopped during the occurrence of a Probable Maximum Flood, as shown in Section 5.1d. This would inevitably cause a failure of the railroad embankment. Also, due to the fact that most railroad embankments are not designed to store water, which is evident at this site inasmuch as the side slopes of the railroad embankment are greater than 1V to 1H,

the pressure of the water on the railroad embankment due to the backup of flood waters from a large storm or the sudden surcharge of water on the embankment due to a sudden failure of Lembeck Lake Dam could cause a failure of the railroad embankment.

e. Ownership

Lembeck Lake Dam is owned privately by Dr. and Mrs. Chang H. Kang. The mailing address is Dr. and Mrs. Chang H. Kang, 14012 Margaux Lane, Chesterfield, Missouri, 63017. Dr. and Mrs. Kang lease the lake and dam property to a group called the Pleasant View Lake Association that also maintain the dam. Dr. and Mrs. Kang were not the owners when the dam was built.

f. Purpose of Dam

The purpose of the dam is to impound water for recreational use as a private lake.

g. Design and Construction History

According to Mr. John J. Lembeck, the son of the original owner of the dam, the dam was built by a Wheatley Construction Company of Dupo, Illinois in a period of 1.5 months between February and March of 1958. A date of May 13, 1958 was inscribed in the concrete headwall of the low-level outlet indicating that the sluice gate and the headwall were installed after the dam embankment was completed.

Mr. Lembeck said that the soil for the dam embankment was taken from the hill at the north side of the reservoir. The topsoil was removed and stockpiled in order to be placed later on the dam embankment. The soil used for the dam was primarily a red clay. The fill material was placed on the embankment by rubber-tired scrapers pulled by bulldozers and compacted by a sheepsfoot roller. Mr. Lembeck stated that it was relatively rainy during the period

when the dam embankment was constructed. No compaction tests were made during the construction of the dam.

A core trench was constructed along the axis of the dam to solid bedrock and keyed into the right abutment. According to Mr. Lembeck, there were no plans or specifications for the dam.

Mr. Duke Sutterfield, one of the previous owners of the dam, said that improvements were made to the spillway of the dam in 1973. Riprap was placed at the base of the spillway weir and a new concrete slab placed over the riprap.

According to Dr. Kang, a weir wall across the spillway discharge channel was washed out during a two to three inch rainstorm about five years ago. Remnants of the weir wall were seen in the discharge channel (see Photo 9). The south side of the spillway channel was also damaged during this rainstorm. Dr. Kang had riprap placed in this area to prevent further damage to the discharge channel slope and dam (see Photo 5). There have not been any other changes or modifications to the dam.

h. Normal Operational Procedures

Lembeck Lake Dam is used to impound water for recreation. According to Dr. Kang, the sluice gate of the low-level outlet is opened during the winter months to lower the water level in the reservoir to kill aquatic plants and vegetation that grow on the bottom and sides of the reservoir. The gate is then closed at the end of the winter months and the water level is allowed to rise and remain as high as possible. The water level in the reservoir is controlled by rainfall, runoff, evaporation, the elevation of the spillway crest and the operation of the low-level outlet. The reservoir is also fed by three natural springs, according to Dr. Kang.

1.3 Pertinent Data

a. Drainage Area (square miles): 3.4

b. Discharge at Damsite

Estimated experienced maximum flood (cfs):	Unknown
Estimated ungated spillway capacity with reservoir at top of dam elevation (cfs):	2503

c. Elevation (Feet above MSL)

Top of dam (minimum):	550 (assumed)*
Spillway crest:	544.9
Low-level outlet:	536.6
Normal Pool:	544.9
Maximum Experienced Pool:	Unknown
Observed Pool:	536.7

d. Reservoir

Length of pool with water surface at top of dam elevation (feet):	2400

e. Storage (Acre-Feet)

Top of dam (minimum):	208.0
Spillway crest:	117.0
Low-level outlet:	47.5
Normal Pool:	117.0
Maximum Experienced Pool:	Unknown
Observed Pool:	48.0

f. Reservoir Surfaces (Acres)

Top of dam (minimum):	25.0
Spillway crest:	11.5
Low-level outlet:	7.0
Normal Pool:	11.5
Maximum Experienced Pool:	Unknown

Observed Pool: 7.0

g. Dam

Type:. Rolled, Earthfill

Length:. . . . . 590 feet

Structural Height: . . . . 26.4 feet

Hydraulic Height**:. . . . . 26.4 feet

Top width: . . . . 17 feet

Side slopes:

Downstream. . . . . 1V to 2.5H (measured)

Upstream. . . . . 1V to 3.5H (above the water surface)

Zoning:. . . . . Homogeneous

Impervious core: . . . . N.A.

Cutoff:. . . . . A core trench excavated to bedrock, according to Mr. Lembeck

Grout curtain: . . . . None

Volume:. . . . . 21,200 cu.yds. (estimated)

h. Diversion and Regulating Tunnel. . . . None

i. Spillway

Type:. Parabolic-shaped, concrete-lined, broad-crested weir with an earth- and rock-cut channel, uncontrolled.

Location:. . . . . Left abutment

Length of crest: . . . . N.A.

Top Width: . . . . 80.0 feet

Depth: . . . . 2.0 feet

Crest Elevation (feet above MSL):. . . 544.9

j. Regulating Outlets

Type:. Low-level outlet

Location:. . . . . 220 feet to the left of the right abutment

Length:. . . . . Unknown

Closure: . . . . 25 inch square, sluice gate

Maximum Capacity:. . . . . Unknown

* No exact elevation is known for the top of dam, therefore, an elevation was estimated from the Vineland, Missouri, U.S.G.S. Quadrangle sheet (Advance Print). This estimated elevation is referred to as an assumed elevation. All other elevations were determined from the assumed top of dam elevation and field measurements.

** The hydraulic height of the dam is the vertical distance from the lowest point on the downstream toe to the top of dam or the maximum water surface, if below the top of dam.

SECTION 2: ENGINEERING DATA

2.1 Design

No design drawings or calculations are available for the dam and appurtenant structures.

2.2 Construction

No documented data are available concerning the construction of the dam and appurtenant structures, other than the construction history given in Section 1.2g. Mr. Lembeck had a set of slides that were taken during the construction of the dam; however, they were primarily general overviews of the dam embankment and were of little or no help in the preparation of this report.

2.3 Operation

No operational records or data are available for Lembeck Lake Dam.

2.4 Evaluation

a. Availability

The availability of engineering data consists of the State Geological Maps, a general soils map of the State of Missouri published by the Soil Conservation Service and U.S.G.S. Quadrangle Sheets. No design drawings, design computations, construction data, or operation data are available.

b. Adequacy

The conclusions presented in this report are based on field measurements, past performance and present condition of the dam. The available data including the field measurements taken by the field inspection team are considered adequate to evaluate the hydraulic and hydrologic capabilities of the dam. Seepage and stability analyses comparable to the requirements of the "Recommended Guidelines for Safety Inspection of Dams" were not available, which is considered a deficiency.

c. Validity

No valid documented engineering data were available pertaining to the design or construction of the dam and appurtenant structures.

SECTION 3: VISUAL INSPECTION

3.1 Findings

a. General

A visual inspection of the Lembeck Lake Dam was made on March 5, 1981. The following persons were present during the inspection:

Name	Affiliation	Disciplines
Mark Haynes, P.E.	PRC Engineering Consultants, Inc.	Soils
Jerry Kenny	PRC Engineering Consultants, Inc.	Hydraulics and Hydrology
James Nettum, P.E.	PRC Engineering Consultants, Inc.	Civil-Structural and Mechanical
Razi Quraishi, R.P.G.	PRC Engineering Consultants, Inc.	Geology
John Lauth, P.E.	PRC Consoer Townsend, Inc.	Civil - Structural

Specific observations are discussed below.

b. Dam

The overall condition of the dam appears to be fair; however, some items of concern were observed and are described below.

The top of dam appears to be adequately protected against surface erosion by a well maintained grass cover (see Photo 2). No depressions or cracks indicating a settlement of the embankment were apparent. The variation in elevation across the top of dam did not appear to be due to an instability of the embankment. The top of dam is occasionally used as an access road; however, no damage generally associated with vehicular traffic across an earthen structure was observed. No significant deviation in the horizontal alignment was apparent. No evidence indicating that the dam has ever been overtopped was observed.

The upstream slope is not protected by riprap; consequently, the slope has been eroded due to wave action leaving scarps up to one-foot high in some areas (see Photo 4). Due to the water level in the reservoir on the day of the inspection, a comprehensive inspection of the slope was achieved. The slope above the normal water surface level was adequately protected against surface runoff erosion by a good, tall grass cover. Several small cedar trees were also observed above the normal water surface level (see Photo 1). No bulges, depressions or cracks indicating an instability of the embankment or foundation were observed on the slope. The effect of drawing down the reservoir has had no apparent effect on the stability of the embankment. Debris, which included a large pile of driftwood and trash at the south end of the dam, was observed along the slope at the normal water surface (see Photos 1 and 4).

The downstream slope of the dam appears to be adequately protected from surface runoff erosion by an unmaintained grass cover. Large vegetation ranging from brush to large sized trees was also observed on the slope (see Photo 3). The vegetation on the

slope hampered a comprehensive inspection of the slope; however, no depressions, bulges or cracks indicative of a slope movement were apparent on the slope. No seepage was observed either on the slope or along the downstream toe of the dam. The toe of the embankment was severely eroded near the outlet of the low-level outlet, as further described in Section 3.1d (see Photo 16).

The right abutment slopes gently upward from the dam. No instabilities or seepage were observed on the right abutment; however, one erosion gully was observed along the downstream, embankment/right abutment contact. The left abutment along the left side of the spillway discharge channel and in the vicinity of the dam was fairly steep, as indicated by slopes greater than 1V to 1H and showed signs of some erosion; however, the steepness of the slope and the apparent erosion does not appear to have any effect on either the safety of the dam or the safe operation of the spillway. No other instabilities or seepage were observed along the left abutment.

No evidence of burrowing animals was apparent on the embankment or either abutment.

c. Project Geology and Soils

(1) Project Geology

The damsite is located on Whitehead Creek in the Salem Plateau section of the Ozark Plateaus Physiographic Province. Deep dissection of topography by major streams is one of the important characteristics of the Salem Plateau section. There is a wide distribution of dolomites and limestones in the Salem Plateau. Cuestaform topography is exhibited in this plateau section consisting of two major escarpments, namely the Crystal Escarpment and Burlington Escarpment. Deep dissection in dolomites and limestones is a major factor in the development of many springs in this area. A major component of surface discharge of water to the Lembeck Lake Dam is contributed by the springs.

The topography in the vicinity of the damsite is rolling to hilly with U- to V-shaped valleys. Elevations of the ground surface range from 861 feet above M.S.L. nearly 2.9 miles southwest of the damsite to 550 feet above M.S.L. at the damsite. The reservoir slopes are generally from 8- to 22-degrees from horizontal. The reservoir slopes are stable and the reservoir appears to be watertight. The area near the damsite is covered with residual soil deposits consisting of a reddish-brown, moderately plastic, silty clay with frequent 1/4 inch rock fragments.

The regional bedrock geology beneath the residual soil deposits in the damsite area as shown on the Geologic Map of Missouri (1979) (see Plate 6) are of the Ordovician age rocks consisting of Decorah Formation, St. Peter Sandstone, Powell Dolomite, Cotter Dolomite, Roubidoux Formation, and Gasconade Dolomite; and the Cambrian age rocks consisting of Eminence Dolomite, Potosi Dolomite, and Franconia and Bonneterre Formations. The predominant bedrock underlying the residual soil deposits in the vicinity of the damsite are the Ordovician age rocks consisting of Powell Dolomite, Roubidoux Formation, Gasconade Dolomite and St. Peter Sandstone.

Outcroppings of Ordovician Powell Dolomite (light- to brownish-gray, fine grained, very hard, thinly bedded, slightly weathered to unweathered, cherty dolomite with frequent vugs) are exposed in the discharge channel of the spillway (see Photos 7, 10 and 11).

No faults have been identified at the damsite. The closest trace of a fault to the damsite is the Ste. Genevieve fault system nearly two miles southwest of the damsite. The Ste. Genevieve fault had its last movement in the post-Pennsylvanian time. Thus, the fault system has no effect on the damsite.

No boring logs or construction reports were available that would indicate foundations conditions encountered during construction. Based on the visual inspection and conversations with Mr. Lembeck, the embankment probably rests on Ordovician Powell Dolomite bedrock with the core trench excavated to the bedrock. The spillway was cut into the left abutment and is founded on the bedrock of cherty dolomite. The low-level outlet pipe rests on the compacted embankment fill.

(2) Project Soils

According to the "Missouri General Soil Map and Soil Association Description" published by the Soil Conservation Service, the materials in the general area of the dam belong to the soil series of Union-Goss-Gasconade-Peridge in the Ozark Border Association. The soils are basically formed from loess deposits and weathered bedrock. These soils vary from a slowly permeable silty clay to moderately permeable silt loam.

Material removed from the embankment slopes was a reddish- to yellowish-brown, moderately plastic, silty clay with traces of fine to medium sand and traces of rock fragments ranging from 1/4 to one inch. Based upon the Unified Soil Classification System, the soil would probably be classified as a CL. This is an impervious soil type, which generally has the following characteristics: a coefficient of permeability less than one foot per year, medium shear strength, and a high resistance to piping.

d. Appurtenant Structures

(1) Spillway

The concrete surface of the weir was rough due apparently to the mix composition and finishing techniques and not from weathering (see Photo 8). No large cracks were seen in the crest portion of the weir control section. But, the joint along the downstream edge of the weir and the downstream apron has separated and a part of the concrete of the apron has broken off (see Photos 8 and 9). The failure of this portion of the weir appears to have resulted from differential settlement caused by undermining of the weir foundation and the lack of reinforcement in the concrete.

The bedrock-lined channel beginning just downstream of the broad-crested weir has undergone considerable erosion since the time of its construction (see Photo 7). This was evidenced by the remnants of a second weir that failed five years ago, according to Dr. Kang (see Photo 9). The bottom of this concrete weir that is still in place is perched two feet above the current channel bottom. The weir extended across the spillway channel slightly downstream of the dam axis. It is assumed that the bottom of the weir was set on the bedrock lining of the channel. It appears that the weir fractured near its right abutment. The majority of the structure was seen lying along the left edge of the spillway channel (see Photo 7).

The right end of the concrete weir abuts a concrete retaining wall that extends along part of the right spillway channel bank near the dam embankment. The foundation of the wall has failed; the concrete is cracked; and the wall is inclined about 30- to 45-degrees towards the spillway (see Photo 9). It is not known if the spillway channel erosion was solely responsible for the failure of the wall, but it certainly was a contributor. Riprap has been placed along the right side of the spillway channel in an effort to protect the embankment from erosion, according to Dr. Kang

(see Photo 5). The inclination of the retaining wall has displaced some of the riprap exposing unprotected portions of the embankment. The inevitable complete collapse of the wall could expose additional embankment areas to the erosive action of spillway flows.

Portions of the spillway discharge channel banks have eroded in the region downstream of the dam. The channel here is irregularly surfaced with bedrock, rubble and obstructed with trees and brush (see Photo 10). Even though both sides of the channel were eroded, the bank adjacent to the railroad embankment was in the worst condition.

(2) Low-level Outlet

There appeared to be no leakage around the sluice gate as there was no discharge through the outlet pipe; however, there was very little head on the gate the day of the inspection. The headwall has been undermined slightly due probably to wave action (see Photo 13). The gate appears to be operable for on a reconnaissance trip to the damsite the gate was slightly open and water was discharging through the outlet pipe. On the day of the inspection, the gate was closed and the reservoir level was slightly above the invert of the outlet. Grease on the gate stem also indicates that the gate had been operated recently (see Photo 13). The handwheel operator for the gate was not observed at the damsite.

The pedestals supporting the gate stem and encasement pipe were all canted in varying degrees. The tops of three pedestals were broken off precluding any lateral support for the stem (see Photo 12). The pedestal at the normal water surface level was displaced and damaged to an extent that no support at all was provided for the stem (see Photo 15). All the pedestals showed honeycombing resultant from placement, but little weathering was evident.

The outlet end of the CMP was cantilevered out eight feet from the embankment (see Photo 16). The asphalt coating on the outside of the CMP was sloughing off although no rust was evident. No piping of the embankment material was observed around the downstream end of the outlet pipe. Discharge from the outlet pipe into the stilling basin has eroded the toe of the dam back to where the pipe emerges from the embankment. The remaining sides of the stilling basin were near vertical and raw. The outlet channel from the stilling basin was obstructed by tree roots and debris.

e. Reservoir Area

The reservoir water surface elevation at the time of the inspection was 536.7 feet above M.S.L. The reservoir has a normal water surface elevation of 544.9 feet above M.S.L. and a surface area of 11.5 acres at the normal water surface level.

The rim appeared to be stable with no erosional or stability problems observed (see Photo 17). The land around the reservoir slopes gently to moderately upward from the reservoir rim and is mostly wooded with grass cover. No houses are built near the reservoir shoreline. No evidence of excessive siltation was observed in the reservoir on the day of the inspection.

f. Downstream Channel

The downstream channel between the dam and the railroad embankment is not well defined and is obstructed with trees and debris. The channel passes through a 10-feet tall by 10-feet wide masonry arch culvert under the railroad embankment. The channel then discharges into Joachim Creek, which is a fairly wide channel.

3.2 Evaluation

The visual inspection uncovered nothing which was felt to be sufficiently significant to indicate a need for immediate remedial action. However, the following conditions were observed which could adversely affect the dam in the near future and will require maintenance within a reasonable period of time.

1. The failure of the downstream apron of the broad-crested weir does present a safety hazard to the dam. Future flows over the weir will continue to undermine the foundation causing further differential settlement. Vehicular traffic over the unreinforced weir will accelerate the inevitable break up and collapse of the concrete surface. The total failure of the weir could imperil the dam.

2. The erosion in the spillway channel that has contributed to the failure of the original concrete weir and retaining wall and the apparent instability of the adjacent embankment does not present an immediate safety hazard to the dam. But, the progressive nature of the erosion could eventually cause sufficient damage to jeopardize the dam.

3. The erosion in the lower reach of the spillway channel does not currently endanger the dam, but will worsen with time. Currently, the greatest hazard resulting from this erosion is to the adjacent railroad embankment.

4. The loss of support for the gate stem caused by the instability of the concrete pedestals could disable the low-level outlet. Whatever reservoir control that is provided by the outlet would then be eliminated.

5. The erosion of the embankment toe in the stilling basin and the undermining of the headwall of the low-level outlet is a hazard to the stability of the system and the dam.

6. The obstruction of tree roots and debris in the discharge channel of the low-level outlet reduces the capacity of the channel.

7. The wave erosion on the upstream slope does not appear to affect the stability of the dam in its present condition. However, continual erosion of the slope can only be detrimental to the structural integrity of the dam.

8. The trees and brush on the embankment slopes, especially on the downstream slope, pose a potential danger to the safety of the dam if allowed to grow. A tall, dense growth of vegetation on the embankment hinders a comprehensive inspection of the dam and potential problems could go undetected. And, the root system of large trees present possible paths for piping through the embankment and can also do damage to the embankment by being uprooted during a storm.

9. The erosion along the embankment/right abutment contact does not jeopardize the stability of the dam in its present condition; however, continual erosion in this area can only be detrimental to the stability of the dam.

10. The driftwood and debris observed on the upstream slope could have an adverse affect on the safety of the dam and the railroad embankment downstream of the dam. During high flows through the spillway, the driftwood and any floating debris will probably pass through the spillway safely; however, the driftwood could obstruct the culvert under the railroad embankment which would increase the potential of a failure of the railroad embankment during large floods. Also, the pile of driftwood and debris at the south end of the dam could allow potential problems in the area to go undetected.

SECTION 4: OPERATIONAL PROCEDURES

4.1 Procedures

According to Dr. Kang, the sluice gate of the low-level outlet is opened during the winter months to lower the water level in the reservoir. The reservoir level is lowered in order to eliminate the growth of aquatic plants and vegetation on the bottom and sides of the reservoir. The gate is then closed at the end of the winter months and the water surface is allowed to rise and remain as high as possible.

4.2 Maintenance of Dam

Dr. and Mrs. Kang lease the lake and dam property to a group called the Pleasant View Lake Association, which also maintains the dam. The Association normally cuts the grass and brush from the top and slopes of the dam about once or twice a year. However, large vegetation ranging from brush to large trees was growing on the downstream slope of the dam. A few small cedar trees are also growing on the upstream slope.

Some repair work has been done in the spillway, as described in Section 1.2g. However, the spillway is still in need of further repair.

4.3 Maintenance of Operating Facilities

The sluice gate of the low-level outlet is the only operating facility at the dam. The gate stem is periodically oiled to increase the ease of operation of the system. Due to the condition of the concrete support pedestals and the outlet area of the system, the maintenance of the low-level outlet, however, appears to be somewhat lacking.

4.4 Description of Any Warning System in Effect

The inspection team is not aware of any warning system in effect for this dam, such as an electrical warning system or manual warning notification plan.

4.5 Evaluation

The maintenance of Lembeck Lake Dam seems to be somewhat lacking. The remedial measures described in Section 7 should be undertaken within a reasonable period of time to improve the condition of the dam.

SECTION 5: HYDRAULIC/HYDROLOGIC

5.1 Evaluation of Features

a. Design

No hydrologic and hydraulic design data are available for Lembeck Lake Dam. The sizes of physical features utilized to develop the stage-outflow relation for the spillway and overtopping of the dam were prepared from field notes and sketches prepared during the field inspection. The reservoir elevation-area data were based on the U.S.G.S. Vineland, Missouri Quadrangle topographic map (Advance Print, 7.5 minute series). The spillway and overtop release rates and the reservoir elevation-area data are presented in Appendix B.

The hydrologic soil group of the watershed was determined from information available in the U.S.D.A. Soil Conservation Service publication "Missouri General Soil Map and Soil Association Descriptions", 1979. The Probable Maximum Precipitation (PMP) used to determine the Probable Maximum Flood (PMF) was determined by using the U.S. Weather Bureau Publication "Hydrometeorological Report No. 33" (April 1956). The 100-year and the 10-year floods were derived from the 100-year and the 10-year rainfall, respectively, of Ste. Genevieve, Missouri.

b. Experience Data

Records of reservoir stage or spillway discharge are not maintained for this site. However, no evidence was observed which would indicate that the dam had ever been overtopped.

c. Visual Observations

Observations made of the spillway during the visual inspection are discussed in Section 3.1d and evaluated in Section 3.2.

d. Overtopping Potential

Both the Probable Maximum Flood and one-half of the Probable Maximum Flood, when routed through the reservoir, resulted in overtopping of the dam and the subsequent submergence of the dam by the backwater impounded behind the railroad embankment immediately downstream. Due to the submergence of the dam, flows over the dam are controlled by the railroad embankment. Therefore, in order to evaluate the overtopping of the dam, the railroad embankment alone was analyzed. The reported depths and durations of submergence and the peak outflows during submergence were determined by transferring the results of the analysis of the railroad embankment to the dam (see Appendix B for addition details of the analysis). The peak inflows of the PMF and one-half of the PMF are 21,447 cfs and 10,723 cfs, respectively. The peak outflow discharges for the PMF and one-half of the PMF are 21,111 cfs and 8,778 cfs, respectively. The maximum capacity of the spillway just before overtopping the dam is 2,503 cfs. The dam is submerged by 14.28 and 12.29 feet during the occurrence of the PMF and one-half of the PMF, respectively. The total duration that the dam is submerged is 8.33 hours during the occurrence of the PMF and 6.0 hours during one-half of the PMF. The spillway/reservoir system of Lembeck Lake Dam is capable of accommodating a flood equal to approximately 13 percent of the PMF just before overtopping the dam and will also accommodate the ten-percent chance flood (10-year flood) without overtopping the dam. The dam is overtopped by a depth of approximately one foot during the occurrence of the one-percent chance flood (100-year flood). The total duration of overtopping is at least one hour.

The surface soils on the embankment consist of a silty clay protected by a good cover of grass. However, the dam will be overtopped and subsequently submerged by approximately 14.28 feet during the occurrence of the PMF which can cause severe erosion to the embankment due to the high velocity of flow on its downstream slope before submergence occurs and due to turbulence in the area of the embankment after submergence occurs. Severe erosion of the embankment could lead to an eventual failure of the dam. The spillway weir and discharge channel will also receive considerable damage during large flows, as evident by the present damage in the spillway described in Section 3.1d.

The estimated damage zone of Lembeck Lake Dam extends approximately three miles downstream of the dam. Located within the damage zone are at least 24 dwellings, four buildings, one railroad embankment, one state highway (Highway 110), and one railroad terminal. The failure of the dam could cause extensive damage to the property downstream of the dam and possible loss of life should the railroad embankment also fail. The degree of protection to the estimated damage zone provided by the railroad embankment is questionable since this depends on: the strength of the railroad embankment, which was not designed to impound water; the degree of obstruction of the culvert through the railroad embankment; and the overtopping of the railroad embankment itself, as is the case for the PMF and one-half of the PMF.

SECTION 6: STRUCTURAL STABILITY

6.1 Evaluation of Structural Stability

a. Visual Observations

There were no major signs of settlement or distress observed on the embankment or foundation during the visual inspection. The stability of the dam does not appear to be in jeopardy at this time; however, continual deterioration of the dam due to neglect and improper maintenance can only endanger the structural integrity and safety of the dam. The wave erosion on the upstream slope and the erosion along the downstream, right abutment/embankment contact do not appear to endanger the structural stability of the embankment in their present condition; however, continual erosion in these areas can only be detrimental to the embankment. In the absence of seepage and stability analyses, no quantitative evaluation of the structural stability can be made.

The stability of the spillway is questionable. A portion of the broad-crested weir control structure has failed and additional damage in the spillway area is also evident. Although the spillway is unobstructed and should function under limited discharge, a potentially unsafe condition exists.

The stability of the low-level outlet is also questionable. Discharge through the system has seriously eroded the toe of the dam embankment, which endangers the stability of the outlet pipe and the dam. The low-level outlet appears to be able to operate, but its use creates a hazard to the stability of the dam.

b. Design and Construction Data

No design computations pertaining to the embankment were uncovered during the report preparation phase. Seepage and stability analyses comparable to the requirements of the "Recommended Guidelines for Safety Inspection of Dams" were not available. No embankment or foundation soil parameters were available for carrying out a conventional stability analysis on the embankment. No construction data or specifications relating to the degree of embankment compaction were available for use in a stability analysis.

c. Operating Records

No operating records are available relating to the stability of the dam or appurtenant structures. The water level on the day of inspection was 8.2 feet below the crest of the spillway; however, the reservoir is assumed to remain close to full during the summer months.

No evidence was observed that would indicate that the drawing down of the reservoir by the low-level outlet has had any effect on the structural stability of the dam. Nevertheless, it is felt that due to the large size of the low-level outlet and the volume of water stored in the reservoir that drawing down the reservoir by means of the outlet could have an effect of the stability of the dam depending upon the rate of flow through the outlet.

d. Post Construction Changes

The only known modification to the dam or spillway since their original construction was the repair work done in the spillway channel after the original weir wall was washed out (see Section 1.2g). The repair work appears to have enhanced the structural integrity and safety of the spillway channel and the dam. Nevertheless, further repair work is required in the spillway channel. No

other post construction changes to the embankment are known to exist that will affect the structural stability of the dam.

e. Seismic Stability

The dam is located in Seismic Zone 2, as defined in the "Recommended Guidelines for Safety Inspection of Dams" as prepared by the Corps of Engineers (see Plate 10). Seismic Zone 2 is characterized by a moderate earthquake hazard. An earthquake of the magnitude that would be expected in Seismic Zone 2 should not cause significant distress to a well designed and constructed earth dam. Available literature indicates that no active faults exist near the vicinity of the damsite. The maximum recorded historic magnitude earthquake in the immediate vicinity of the damsite was the January 24, 1902 event of magnitude 5 located at a distance of 36 miles northeast of the damsite. This event cannot be correlated with known tectonic structure and is considered to probably be related to the release of accummulated residual strain along the buried pre-Quarternary fault. The attenuation of this event to the damsite would produce a peak ground acceleration of less than 0.05g which would not produce a significant seismic impact on the dam.

SECTION 7: ASSESSMENT/REMEDIAL MEASURES

7.1 Dam Assessment

The assessment of the general condition of the dam is based upon available data and the visual inspection. Detailed investigations, testing, and detailed computational evaluations are beyond the scope of a Phase I investigation; however, the investigation is intended to identify any need for such studies.

It should be realized that the reported condition of the dam is based upon observations of field conditions at the time of the inspection along with data available to the inspection team.

It is also important to realize that the condition of a dam depends upon numerous and constantly changing internal and external conditions, and is evolutionary in nature. It would be incorrect to assume that the present condition of the dam will continue to represent the condition of the dam at some point in the future. Only through continued care and inspection can there be assurance that an unsafe condition could be detected.

a. Safety

The spillway capacity of Lembeck Lake Dam is found to be "Seriously Inadequate". The spillway/reservoir system will accommodate about 13 percent of the PMF without overtopping the dam. If the dam is overtopped and subsequently submerged, the safety of the embankment would be in jeopardy due to the susceptibility of the embankment materials to erosion. High velocity flow on the downstream slope of the dam before submergence occurs and turbulence in the area of the dam after sunbmergence occurs could cause excessive erosion and eventually lead to a failure of the dam. The spillway

system would also receive considerable damage during the occurrence of the PMF.

The overall condition of the dam and appurtenant structures appears to be poor as indicated by the several items of concern which were noted during the visual inspection and which will require attention. A quantitative evaluation of the safety of the embankment could not be made in view of the absence of seepage and stability analyses. The present embankment appears to have performed satisfactorily since its construction without failure or evidence of instability; however, the appurtenant structures have not performed satisfactorily as evident by the partial failure of the existing weir structure, the failure of the original weir wall, the damage noted in the spillway discharge channel and the damage to the embankment at the downstream end of the low-level outlet. No evidence indicating the dam has ever been overtopped was observed. The safety of the dam can only be improved if the deficiencies described in Section 3.2 are properly corrected as described in Section 7.2b.

b. Adequacy of Information

The conclusions presented in this report are based upon field measurements, past performance and the present condition of the dam. Documented information on the design hydrology, hydraulic design, operation, and maintenance of the dam was not available. Seepage and stability analyses comparable to the requirements of the "Recommended Guidelines for Safety Inspection of Dams" were not available, which is considered a deficiency.

c. Urgency

The items recommended in Paragraph 7.2a should be pursued on a high priority basis. The remedial measures recommended in Paragraph 7.2b should be accomplished within a reasonable period of time.

d. Necessity for Phase II Inspection

Based upon results of the Phase I inspection, and if the remedial measures recommended in Paragraph 7.2 are undertaken, a Phase II inspection is not felt to be necessary.

7.2 Remedial Measures

a. Alternatives

There are several options that may be considered to reduce the possibility of dam failure or to diminish the harmful consequences of such a failure. Some of these options are:

1. Increase both the spillway capacity of the dam and the culvert capacity of the railroad embankment to pass the PMF without overtopping or submerging the dam. It is acknowledged that the owner of the dam has no control over or responsibility for modifications made to the railroad embankment.

2. Increase the height of the dam and reduce the capacity of the spillway in order to pass the PMF without overtopping or submerging the dam; an investigation should also include studying the effects that increasing the height of the dam would have on the structural stability of the present embankment. The depth of submergence during the occurrence of the PMF, stated in Section 5.1d, is not the required or recommended increase in the height of dam.

3. A combination of increasing the height of the dam and increasing both the spillway capacity of the dam and the culvert capacity of the railroad embankment in order to pass the PMF, without overtopping or submerging the dam.

b. O & M Procedures

1. The broad-crested weir control section of the spillway should be repaired or replaced with a more stable structure. Vehicular traffic over the existing structure should be prohibited.

2. The failed concrete retaining wall and concrete weir remnant along the right spillway channel bank should be removed and the bank stabilized and protected from erosion.

3. The banks in the lower reach of the spillway discharge channel should be stabilized and protected from erosion. Trees, brush and debris should be removed from the spillway channel and bank areas.

4. The area around the sluice gate headwall should be repaired and protected from wave action.

5. The damaged gate stem pedestals should either be repaired and stabilized or removed and new support measures installed.

6. The low-level outlet stilling basin should be enlarged and adequately protected to prevent future erosion damage. The eroded area of the embankment toe adjacent to the stilling basin should be repaired and protected from future damage. Consideration should be given to adding a supported extension to the existing outlet pipe so that discharge enters the stilling basin downstream of the embankment toe.

7. The stilling basin outlet channel should be cleared of trees, brush and debris and stabilized.

8. The wave erosion on the upstream slope and the erosion gully along the right abutment/embankment contact should be properly repaired and the areas protected from further damage.

9. The trees and brush on the embankment slope, especially on the downstream slope, should be removed from the embankment and regrowth prevented. The grass cover on the embankment, especially on the downstream slope, should be periodically maintained. The grass cover should be retained on the embankment slopes to protect them from erosion and to prevent excessive erosion in the event the dam is overtopped. Removal of large trees should be under the guidance of an engineer experienced in the design and construction of earth dams. Indiscriminate clearing could jeopardize the safety of the dam.

10. Remove the driftwood and debris from the upstream slope.

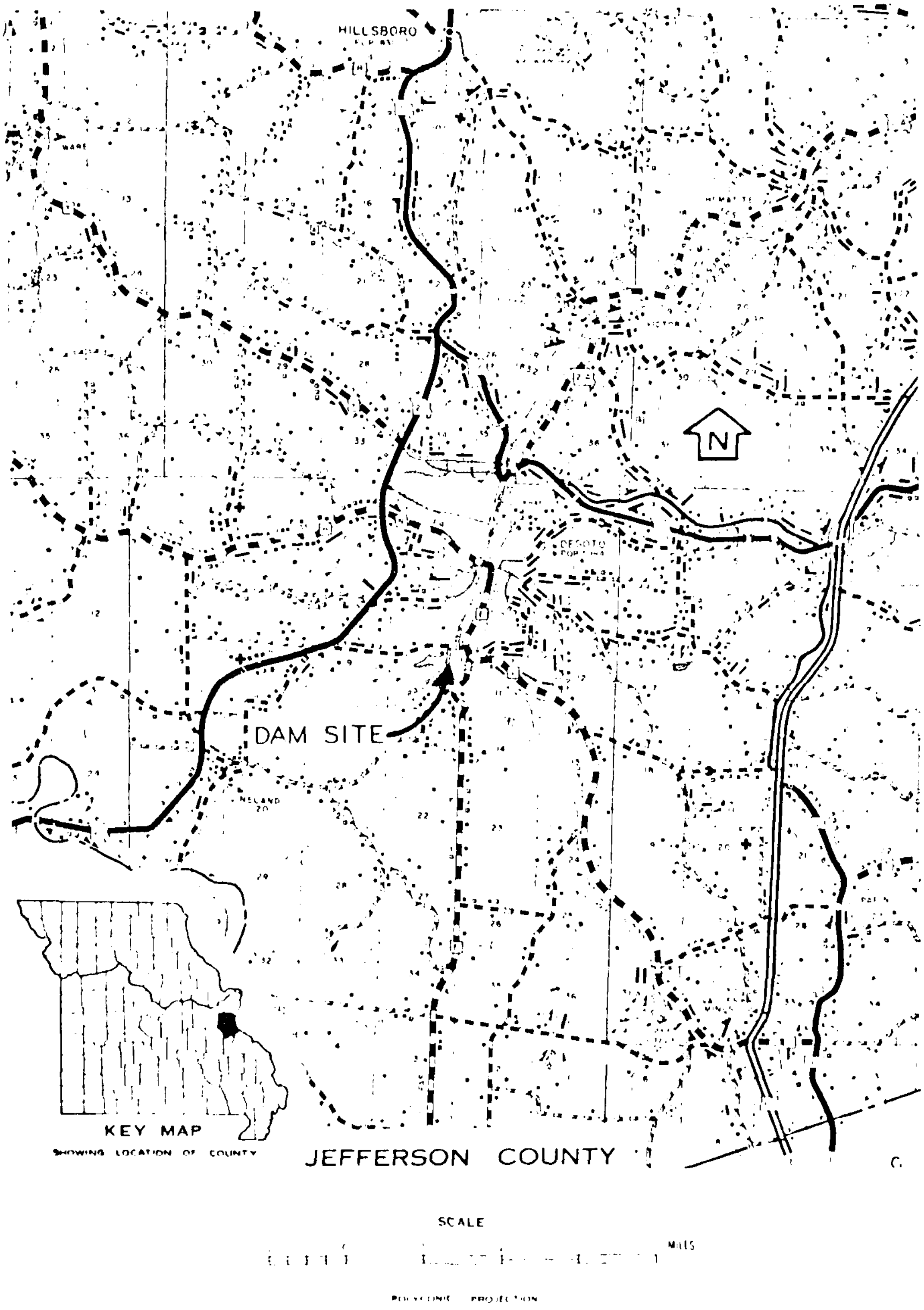
11. Seepage and stability analyses should be performed by a professional engineer experienced in the design and construction of earth dams.

12. The owner should initiate the following programs:

    (a) Periodic inspection of the dam by a professional engineer experienced in the design and construction of earth dams.

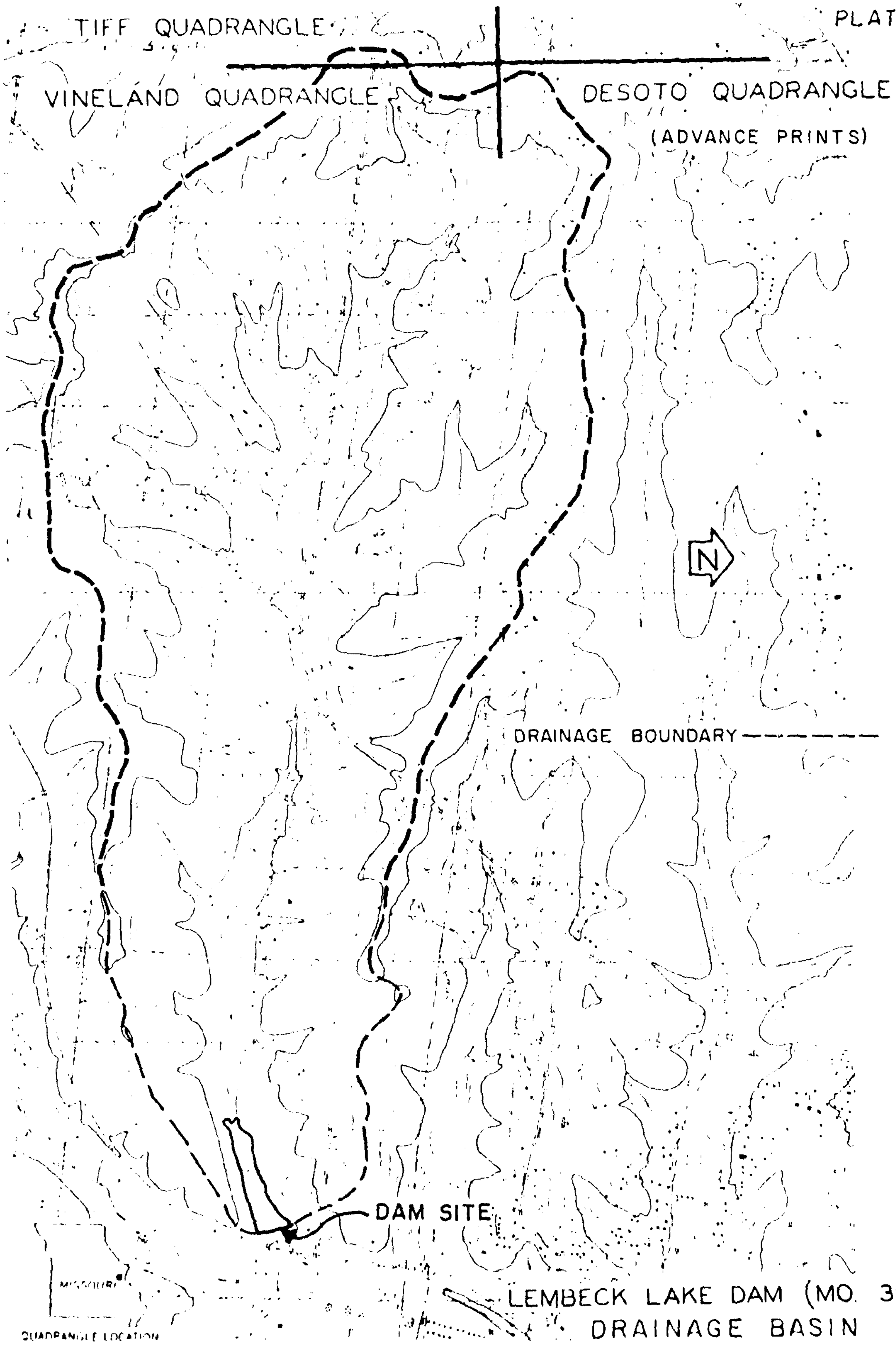
    (b) Set up a maintenance schedule and log all repairs, and maintenance.

PLATES



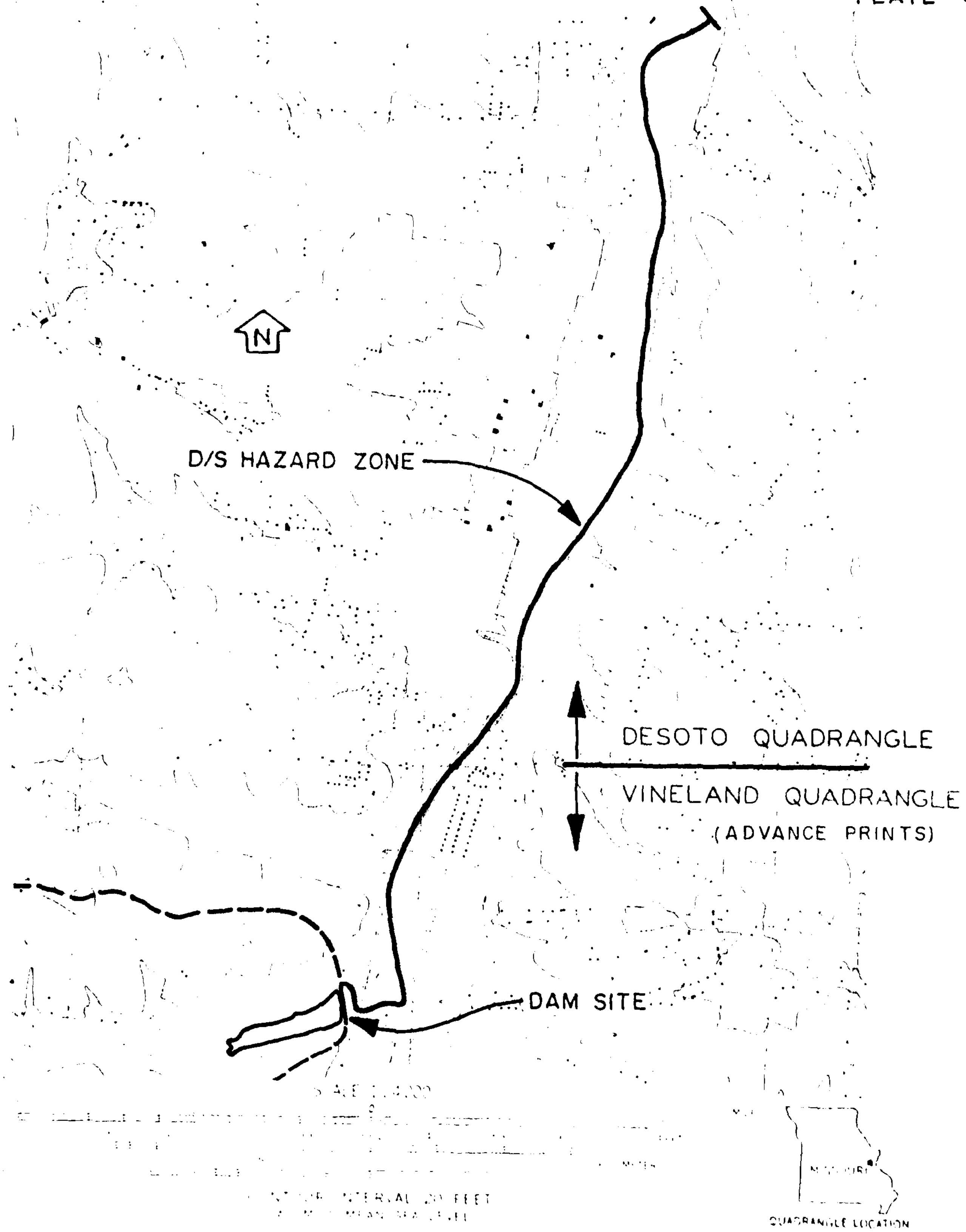
LOCATION MAP – LEMBECK LAKE DAM

MO. 30369



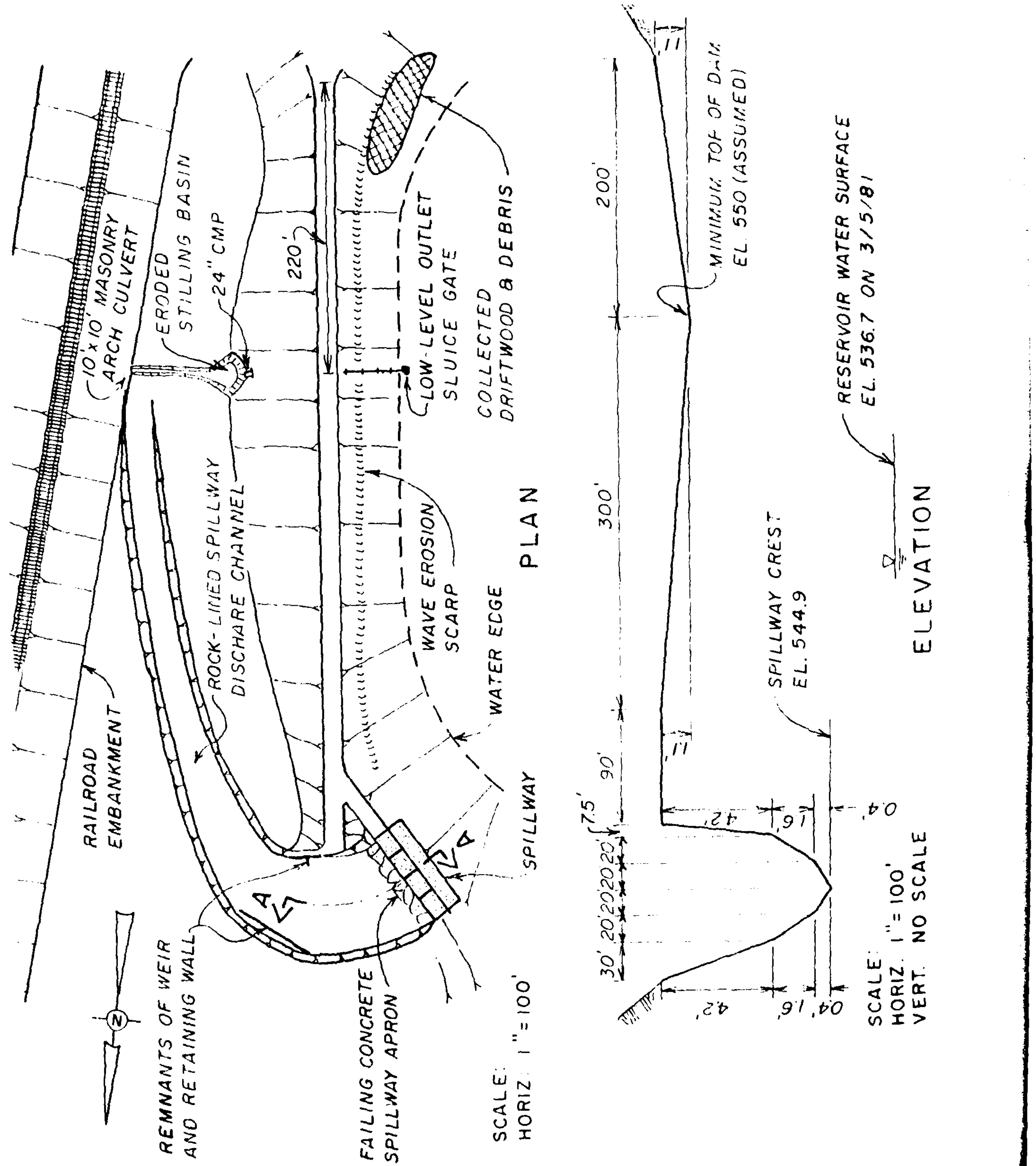
LEMBECK LAKE DAM (MO. 30369)
DRAINAGE BASIN

(FOR SCALE SEE PLATE 3)

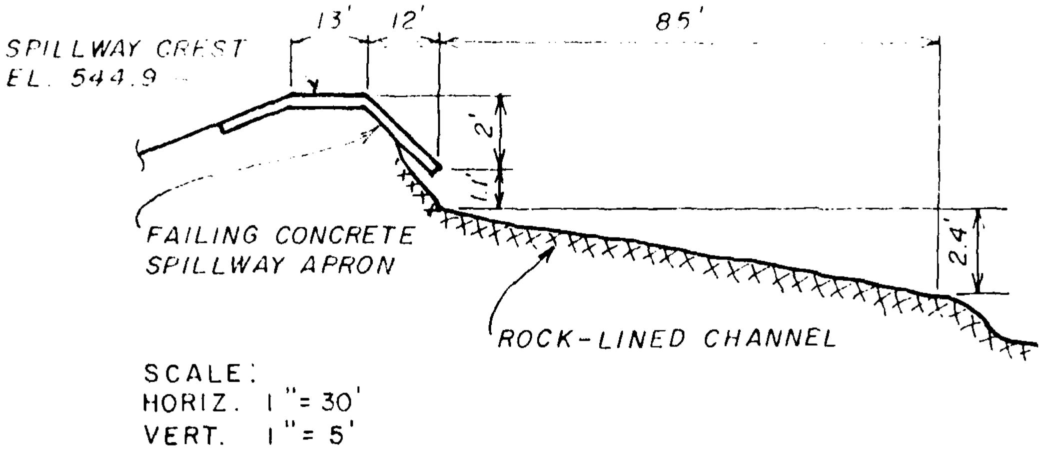


LEMBECK LAKE DAM (MO. 30369)
DOWNSTREAM HAZARD ZONE

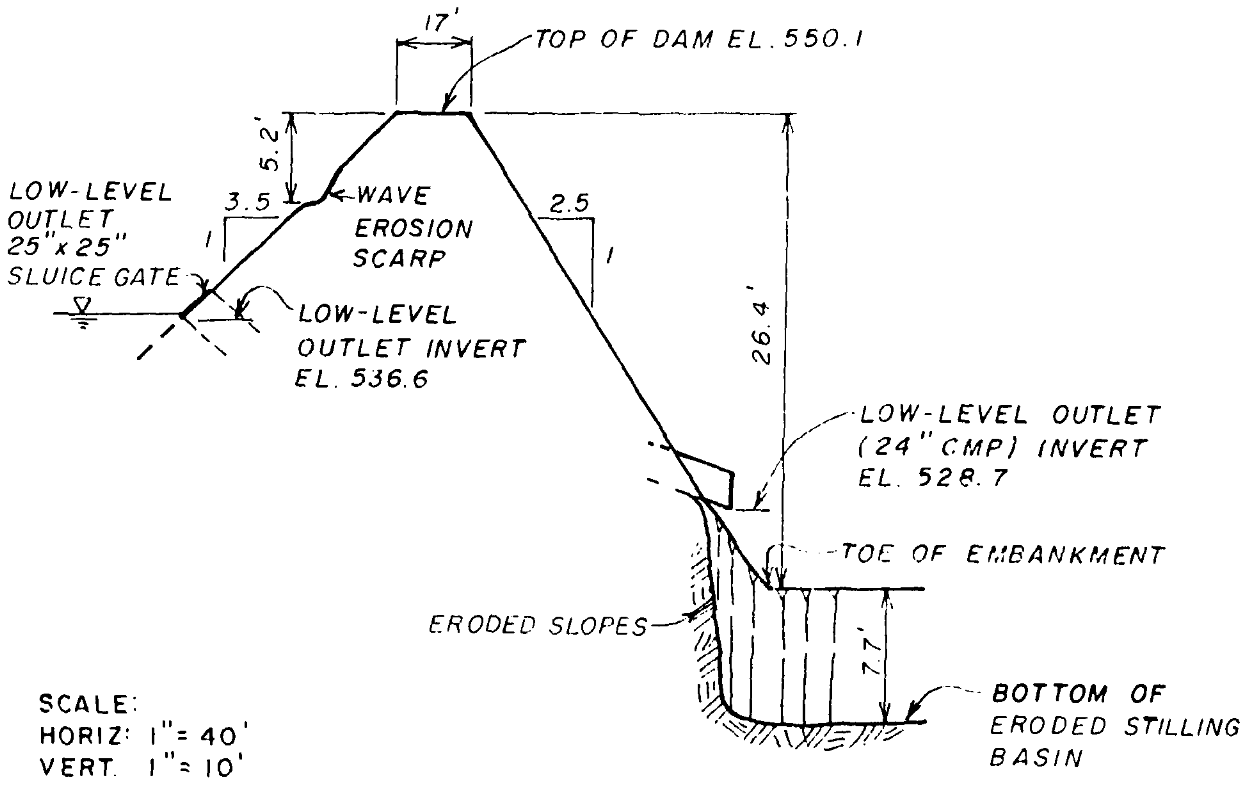
PLATE 4



LEMBECK LAKE DAM (MO. 30369)
PLAN AND ELEVATION
(SHEET 1 OF 2)



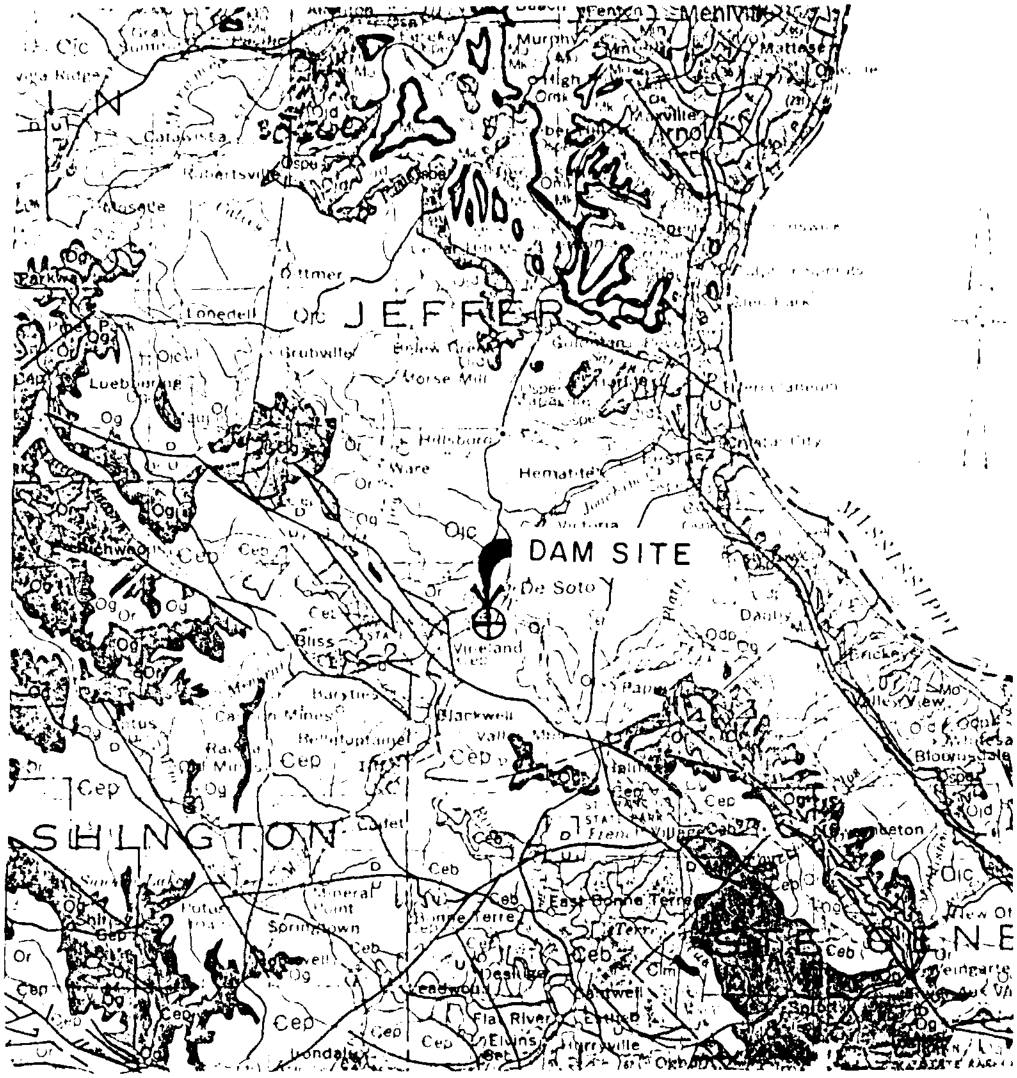
SECTION A-A
(SPILLWAY PROFILE)



MAXIMUM SECTION

LEMBECK LAKE DAM (MO. 30369)
SPILLWAY PROFILE AND MAXIMUM SECTION
(SHEET 2 OF 2)

PLATE 6



SCALE

10 0 10 20 30 40 Miles

⊕ LOCATION OF DAM

NOTE: LEGEND FOR THIS MAP IS ON PLATES 7 THROUGH 9.

REFERENCE:

GEOLOGIC MAP OF MISSOURI
DEPARTMENT OF NATURAL RESOURCES
MISSOURI GEOLOGICAL SURVEY
KENNETH H. ANDERSON, 1979

REGIONAL GEOLOGICAL MAP
OF
LEMBECK LAKE DAM

LEGEND

PERIOD	SYMBOL	DESCRIPTION
QUATERNARY	Qal	ALLUVIUM: SAND, SILT, GRAVEL
	Mm	ST. LOUIS FORMATION: LIMESTONE INTERBEDDED WITH SHALE
	Mm	SALEM FORMATION: LIMESTONE INTERBEDDED WITH SHALE AND SILTSTONE
MISSISSIPPIAN	Mo	KEOKUK - BURLINGTON FORMATION: CHERTY GRAYISH BROWN SANDY LIMESTONE
	Mk	UNDIFFERENTIATED CHOUTEAU GROUP: LIMESTONE
	Mk	HANNIBAL FORMATION: SHALE AND SILTSTONE

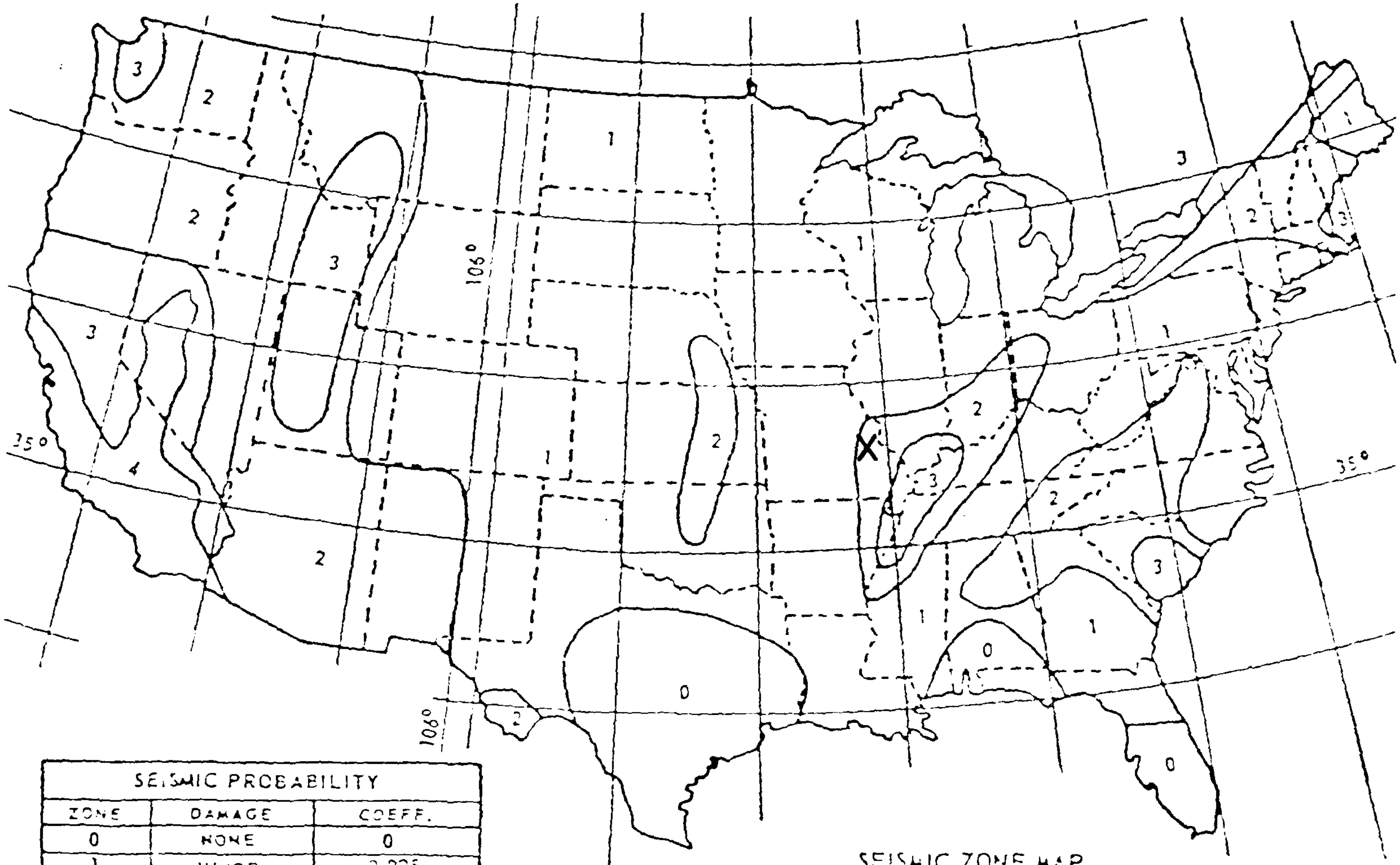
LEMBECK LAKE DAM
PLATE 8
SHEET 2 OF 3

LEGEND

PERIOD	SYMBOL	DESCRIPTION
ORDOVICIAN	Ou	NOIX LIMESTONE
	Omk	MAQUOKETA SHALE, KIMMSWICK LIMESTONE
	Odp	DECORAH FORMATION: GREEN TO GRAY CALCAREOUS SHALE WITH THIN FOSSILIFEROUS LIMESTONE
	Ospe	ST. PETER SANDSTONE, EVERTON FORMATION
	Ojd	JOACHIM DOLOMITE
	Ojc	POWELL DOLOMITE, COTTER DOLOMITE
	Or	ROUBIDOUX FORMATION: INTERBEDS OF CHERTY LIMESTONE AND SANDSTONE
	Og	GASCONADE DOLOMITE

LEGEND

PERIOD	SYMBOL	DESCRIPTION	
CAMBRIAN	Cep	EMINENCE DOLOMITE, POTOSI DOLOMITE	
	€eb	FRANCONIA AND BONNETERRE FORMATION: INTERBEDDED LIMESTONE, CHERTY LIMESTONE, DOLOMITE AND SILTSTONE	
	€lm	LAMOTTE SANDSTONE	
PRECAMBRIAN	i	ST. FRANCOIS MOUNTAINS INTRUSIVE	
	v	ST. FRANCOIS MOUNTAINS VOLCANIC	
	U D	NORMAL FAULT	
	U D	INFERRED FAULT	
	U =	UPTHROWN SIDE,	D = DOWNTHROWN SIDE



SEISMIC ZONE MAP
of
CONTIGUOUS STATES

SEISMIC PROBABILITY		
ZONE	DAMAGE	COEFF.
0	NONE	0
1	MINOR	0.025
2	MODERATE	0.05
3	MAJOR	0.10
4	GREAT	0.15

X APPROXIMATE LOCATION OF LEMBECK LAKE DAM

APPENDIX A

PHOTOGRAPHS TAKEN DURING INSPECTION

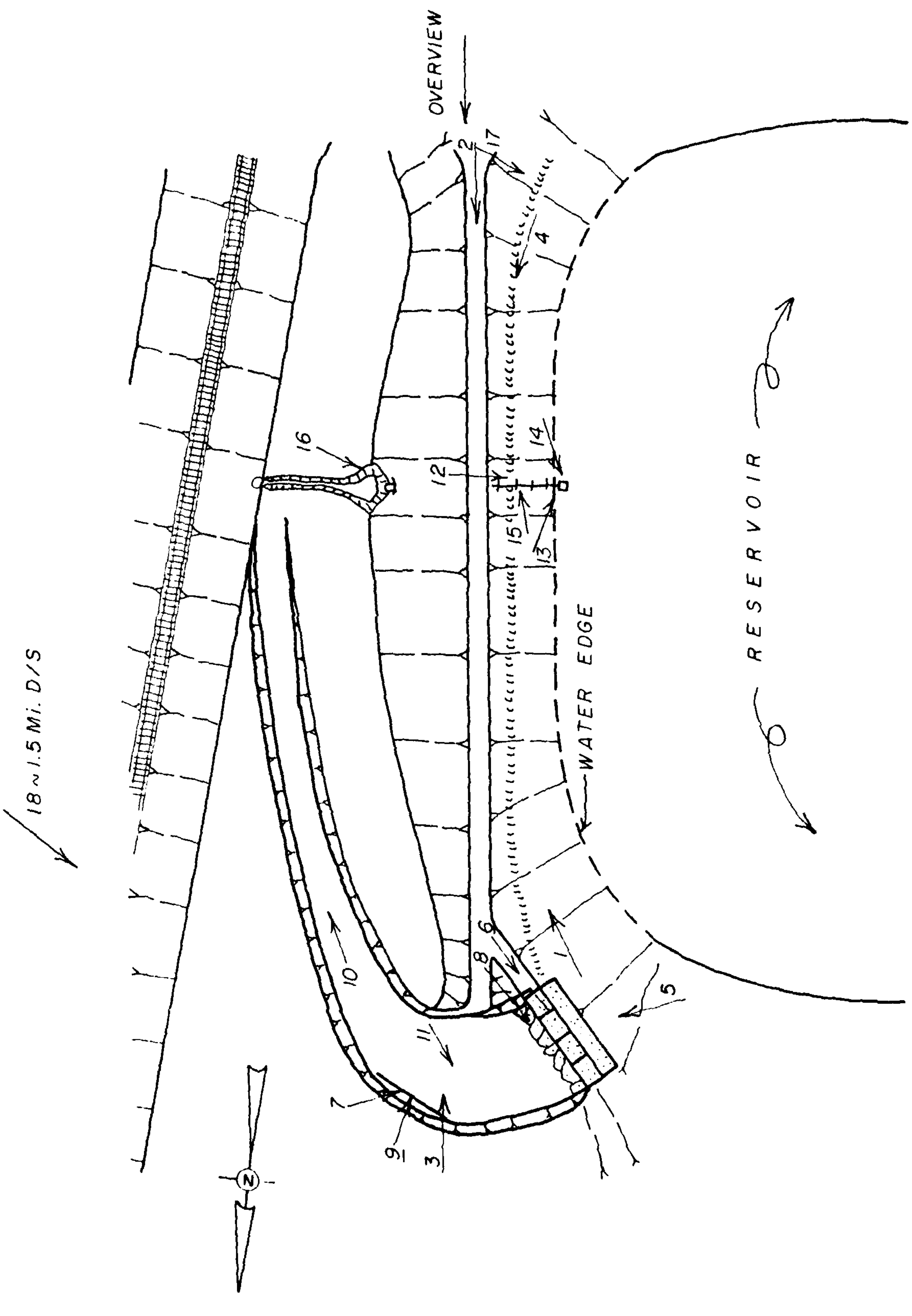


PHOTO INDEX
FOR
LEMBECK LAKE DAM

Photo 1 - View of the upstream slope from the left abutment. Note the pile of driftwood on the slope in the background (right hand side of photo).

Photo 2 - View of the top of dam from the right abutment with the low-level outlet, gate stem encasement pipe and support pedestals on the left and the spillway in the background.

Photo 3 - View of the downstream slope from the left abutment looking across the spillway channel. Note the failed spillway retaining wall and weir in the foregound.

Photo 4 - Close-up view of the upstream slope showing wave erosion scarp and driftwood and debris accumulation.

Photo 5 - View of the spillway control section and access road ascending to the top of the dam. Note railroad embankment in the background.

Photo 6 - View of the spillway broad-crested weir control section from the top of the dam.

Photo 7 - View of the spillway channel looking upstream toward the control section. Note the remnants of the failed concrete weir in the foreground and the erosion of the bedrock in the channel.

Photo 8 - Close-up view of the failure in the spillway broad-crested weir at the downstream end.

Photo 9 - View of the spillway channel looking upstream. A portion of the failed concrete weir is in the foreground. In the background, left to right are the failed retaining wall, the perched portion of the failed concrete weir and the failing backslope of the broad-crested weir.

Photo 10 - View of the spillway discharge channel looking downstream, with the railroad embankment in the background.

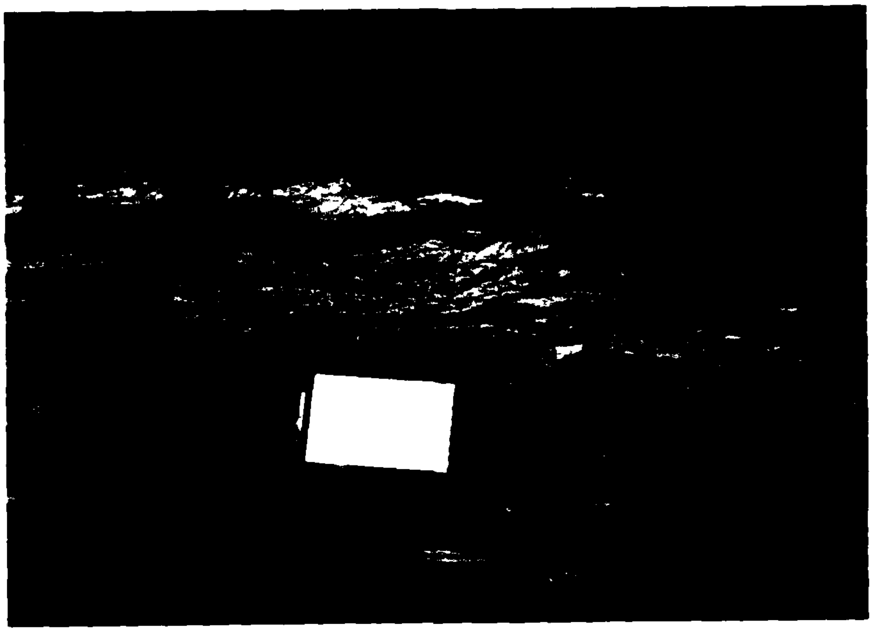


Photo 11 - Close-up view of the thinly bedded dolomite in the spillway channel.

Photo 12 - Close-up view of the gate stem encasement pipe, thrust nut, and support pedestals associated with the low-level outlet.

Photo 13 - Close-up view of the sluice gate, gate stem, gate stem encasement pipe, headwall and support pedestal. Note the erosion around the headwall and the grease on the gate stem just below the end of the encasement pipe.

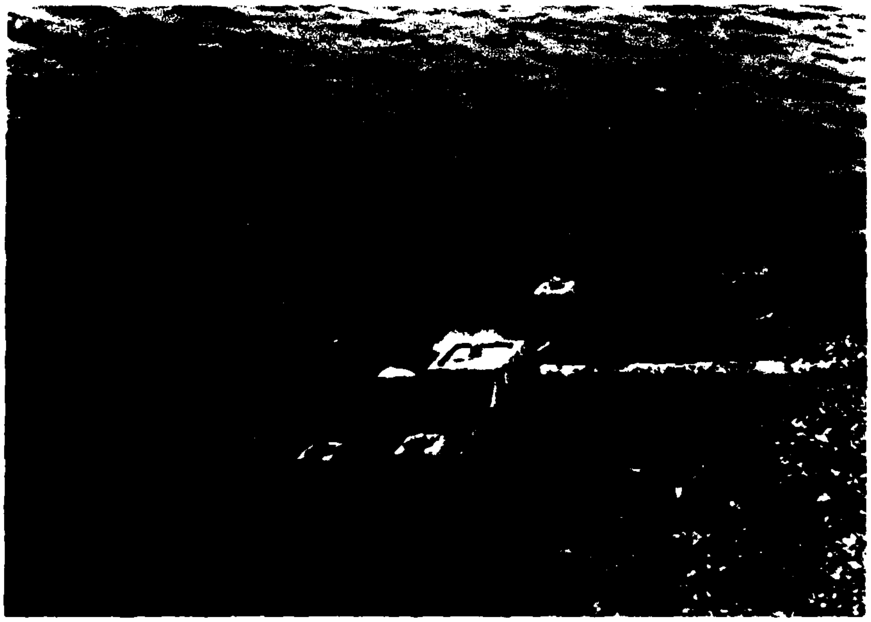


Photo 14 - Close-up view of the sluice gate and gate stem connection.

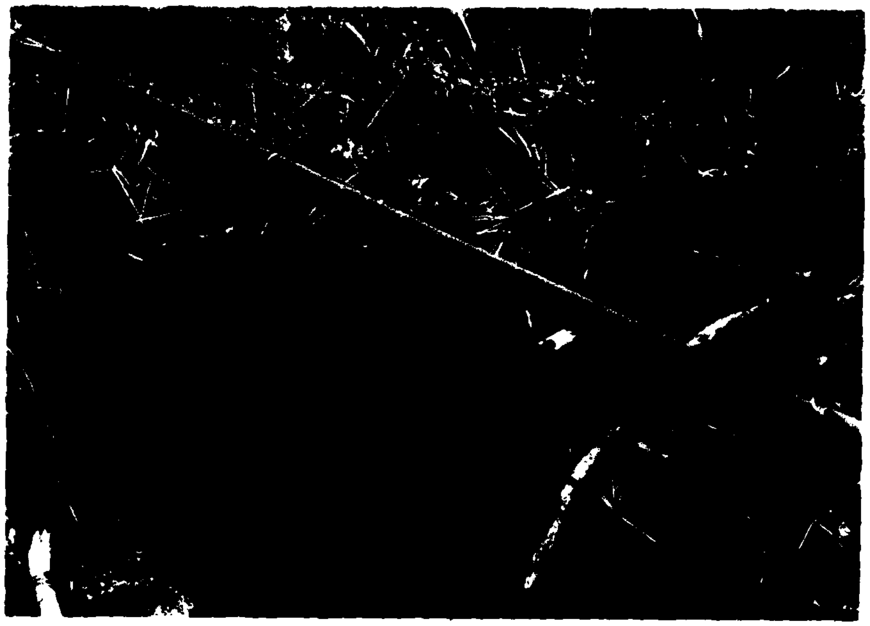


Photo 15 - Close-up view of the gate stem encasement pipe and the support pedestal located at the normal reservoir surface level.

Photo 16 - View of the low-level outlet pipe and the erosion of the downstream toe of the dam.

Photo 17 - View of the reservoir and rim.

Photo 18 - View of several dwellings in the downstream hazard zone looking across Joachim Creek.

APPENDIX B

HYDROLOGIC AND HYDRAULIC COMPUTATIONS

LEMBECK LAKE DAM

HYDROLOGIC AND HYDRAULIC DATA, ASSUMPTIONS AND METHODOLOGY

1. SCS Unit Hydrograph procedures and the HEC-1DB computer program are used to develop the inflow hydrographs. The hydrologic inputs are as follows:

   (a) 24-hour Probable Maximum Precipitation from the Hydrometeorological Report No. 33, and 24-hour 100-year rainfall and 24-hour 10-year rainfall of Ste. Genevieve, Missouri.

   (b) Drainage area = 3.4 square miles.

   (c) Lag time = 0.67 hours.

   (d) Hydrologic Soil Group:
   Soil Group "C".

   (e) Runoff curve number:
   CN = 73 for AMC II and CN = 87 for AMC III.

2. Flow rates through the spillway are based on critical depth assumption. Flow rates over the dam are based on the broad-crested weir equation $Q = CLH^{3/2}$ and critical depth assumption. The downstream embankment was included in the hydraulic analysis to determine its affects on the discharge characteristics of the dam. Due to the tailwater caused by the downstream embankment, the calculated rating curve for the dam could not be used in all of the routings. The following procedures were used for the listed routings:

1) percent PMF and ten-percent chance flood	- calculated rating curve valid for entire routing,

2) PMF and one-half PMF - Lembeck Lake Dam is completely submerged and the discharges at the railroad embankment control; therefore, these floods were not routed through Lembeck Lake. Instead, the capacity curves of the embankment impoundment and the reservoir were combined above the spillway invert elevation of the dam and the floods routed through this revised embankment impoundment. The depth of overtopping at the dam was then calculated based on the maximum water surface elevation determined at the embankment.

3) one-percent chance flood - the dam is not completely submerged, but the tailwater does not affect the the calculated rating curve until after the dam has been overtopped and the peak inflow has been passed.

3. The spillway and the dam overtop rating curves are hand calculated, in accordance with the procedures used in the HEC-1 computer program, and combined as shown on pages B-5 and B-6. This combined rating curve is input into HEC-1DB on the Y4 and Y5 cards. The $L and $V cards are, therefore not used. The development of the rating curve for the downstream embankment is shown on pages B-10 through B-16. The combined rating curve for the downstream embankment is input into HEC-1DB following the same procedure as described above.

4. Floods are routed using the preceeding procedures to determine the capability of the spillway of Lembeck Lake Dam.

ECI-4 **PRC ENGINEERING CONSULTANTS, INC.**

DAM SAFETY INSPECTION / MISSOURI — SHEET NO. ___ OF ___

DAM NAME: LEMBECK Lake Dam — JOB NO. 1283

UNIT HYDROGRAPH PARAMETERS — BY TP — DATE 4/7/81

1) DRAINAGE AREA, A = 3.40 sq. mi = (2176 acres)

2) LENGTH OF STREAM, L = (8.5 " × 2000'/1" = 17000') = 3.22 mi.

3) ELEVATION AT DRAINAGE DIVIDE ALONG THE LONGEST STREAM,

$H_1 = 840$

4) ELEVATION OF RESERVOIR AT SPILLWAY CREST, $H_2 = 544.9$

5) ELEVATION OF CHANNEL BED AT 0.85L, $E_{85} = 700.0$

6) ELEVATION OF CHANNEL BED AT 0.10L, $E_{10} = 560.0$

7) AVERAGE SLOPE OF THE CHANNEL, $S_{AVG} = (E_{85} - E_{10})/0.75L = \frac{700-560}{0.75(17000)} = 0.01$

8) TIME OF CONCENTRATION:

A) BY KIRPICH'S EQUATION,

$t_c = [(11.9 \times L^3)/(H_1 - H_2)]^{0.385} = [11.9 \times (3.22)^3/(840 - 544.9)]^{0.385} = 1.12$ hr.

B) BY VELOCITY ESTIMATE,

SLOPE = 1 % ⟹ AVG. VELOCITY = 2 ft/sec.

$t_c = L/V = \frac{(17000')}{(2'/sec.)(3600\ sec/hr.)} = 2.36$ hrs.

USE $t_c = 1.12$ hrs.

9) LAG TIME, $t_\ell = 0.6\, t_c = 0.67$ hours

10) UNIT DURATION, $D \leq t_\ell/3 = 0.22$ hrs. > 0.166 hr.

USE D = 0.083 (interval necessary for inclusion of R.R. Embankment in analysis)

11) TIME TO PEAK, $T_p = D/2 + t_\ell = 0.71$ hrs

12) PEAK DISCHARGE,

$q_p = (484 \times A)/T_p = \frac{(484 \times 3.4\ mi^2)}{0.71} = 2318$ cfs

PRC ENGINEERING CONSULTANTS, INC.

Missouri Dam Safety — SHEET NO. ____ OF ____

Lemback Lake Dam — JOB NO. 1283

Reservoir Elevation to surface area data — BY JP — DATE 4/6/8[illegible]

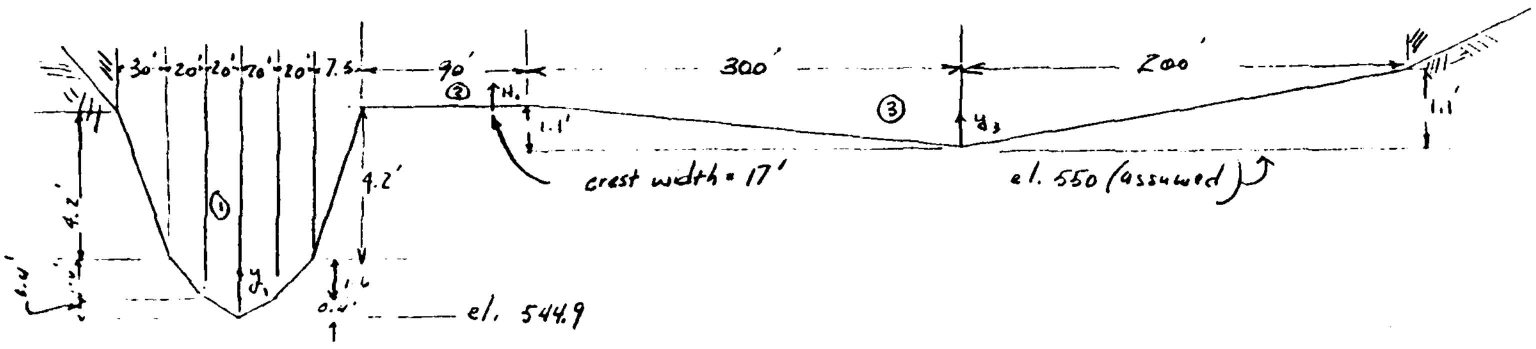
Elevation (ft., MSL)	Surface Area (acres)	Remarks
520.0	0.	Estimated Streambed Elevation
530.0	3.	Interpolated
540.0	9.	Interpolated
544.9	11.5	Spillway Crest
550.0	25.0	Top of dam (Assumed)
560.0	35.5	Measured from Vineland 7.5' Quad
570.	56.0	Interpolated
580.	83.0	Measured from Vineland 7.5' Quad

PRC ENGINEERING CONSULTANTS, INC.

Missouri Dam Safety — SHEET NO ____ OF ____

LEMBECK LAKE Dam — JOB NO. ____

Spillway(s) and overtop rating curve — BY TP DATE 4/7/



Section ① $0 \le y_1 \le 0.4'$, $A = \frac{2}{2}\left(y_1\left(\frac{20}{0.4}y_1\right)\right) = 50y_1^2$, $T = 2\left(\frac{20}{0.4}y_1\right) = 100y_1$, $V = \sqrt{g\frac{A}{T}}$, $Q = VA$

$0.4 < y_1 \le 2.0'$, $A = \left\{\left[40 + \frac{20}{1.6}(y_1 - 0.4)\right](y_1 - 0.4) + \frac{1}{2}(40)(0.4)\right\}$, $T = \left[40 + 2\left(\frac{20}{1.6}\right)(y_1 - 0.4)\right]$, $V = \sqrt{g\frac{A}{T}}$, $Q = VA$

$2.0 < y_1 \le 6.2'$, $A = 8 + 96 + (y_1 - 2.0)\left[(y_1 - 2)\left(\frac{\frac{30}{4.2} + \frac{7.5}{4.2}}{2}\right) + 80\right]$, $T = \left\{\left[2(y_1 - 2)\left(\frac{\frac{30}{4.2} + \frac{7.5}{4.2}}{2}\right)\right] + 80\right\}$

$V = \sqrt{g\frac{A}{T}}$, $Q = VA$

$y_1 > 6.2$, $A = 8 + 96 + \left(\frac{80 + 117.5}{2}\right)(4.2) + (y_1 - 6.2)(117.5)$, $T = 117.5$, $V = \sqrt{g\frac{A}{T}}$, $Q = VA$

$WSEL = y_1 + \frac{V_1^2}{2g} + 544.9$

Section ② for all depths H_2, $Q = CLH_2^{3/2}$, $L = 90'$, $H_2 = WSEL - 551.1$

Section ③ $0 \le y_3 \le 1.1'$, $A = y_3\left[y_3\left(\frac{\frac{300}{1.1} + \frac{200}{1.1}}{2}\right)\right]$, $T = 2(y_3)\left(\frac{\frac{300}{1.1} + \frac{200}{1.1}}{2}\right)$, $V = \sqrt{g\frac{A}{T}}$, $Q = VA$

$y_3 > 1.1'$, $A = 275 + 500(y_3 - 1.1)$, $T = 500'$, $V = \sqrt{g\frac{A}{T}}$, $Q = VA$

$WSEL = y_3 + V_3^2/2g + 550$

PRC ENGINEERING CONSULTANTS, INC.

Missouri Dam Safety — SHEET NO. ___ OF ___

Lembeck Lake Dam — JOB NO. 1223

Spillway and overtop rating curve — BY ___ DATE 4/7/8

WSEL	y_1	A_1	T_1	V_1	$V_1^2/2g$	Q_1	H_2	C_2	Q_2	y_3	A_3	T_3	V_3	Q_3
544.9	0.	0.	0.	0.	0.	0.								
545.4	0.4	8.	40.	2.54	0.1	20.3								
546.0	0.8	26.	50	4.1	0.26	106.6								
546.5	1.2	48	60.	5.1	0.4	244.8								
547.0	1.6	74	70.	5.8	0.52	429.2								
547.8	2.2	120.2	81.8	6.9	0.73	829.4								
548.7	2.8	170.9	87.1	7.9	0.98	1350.1								
549.5	3.4	224.8	92.5	8.8	1.20	1978.2				0	0	0	0	0
550.6	4.2	301.6	99.6	9.9	1.50	2986.	0	0	0	0.48	52.4	218.2	2.8	145.6
551.4	4.8	363.0	105.	10.6	1.70	3848.	0.3	2.97	43.9	1.12	285	500	4.3	1221.
552.2	5.4	427.6	110.4	11.2	1.94	4789.	1.1	3.035	315.1	1.65	550	500.	6.0	3273.
553.3	6.2	518.8	117.5	11.9	2.2	6174.	2.2	3.048	895.1	2.39	917.5	500	7.7	7053.
554.2	6.8	589.3	117.5	12.7	2.5	7484	3.1	3.07	1508.1	2.99	1220	500	8.9	10814.
555.1	7.4	659.8	117.5	13.4	2.8	8841	4.0	3.086	2221.9	3.55	1500	500	9.8	14743.
555.9	8.0	730.3	117.5	14.0	3.0	10331	4.8	3.09	2924.6	4.12	1785	500	10.32	19138

WSEL	Q_T
544.9	0
545.4	20
546.0	107
546.5	245
547.0	429
547.8	829
548.7	1350
549.5	1978
550.6	3132
551.4	5113
552.2	8377
553.3	14122
554.2	19806
555.1	25806
555.9	32394.

1) DRAINAGE AREA, $A = 0.04$ sq. mi = (27 acres)

2) LENGTH OF STREAM, $L = (0.7'' \times 2000'/'' = 1400') = 0.27$ mi.

3) ELEVATION AT DRAINAGE DIVIDE ALONG THE LONGEST STREAM,

$H_1 = 650$

4) ELEVATION OF RESERVOIR AT SPILLWAY CREST, $H_2 = 513.9$

5) ELEVATION OF CHANNEL BED AT 0.85L, $E_{85} = 620$

6) ELEVATION OF CHANNEL BED AT 0.10L, $E_{10} = 523$

7) AVERAGE SLOPE OF THE CHANNEL, $S_{AVG} = (E_{85} - E_{10})/0.75L = \dfrac{(620-523)}{(0.75)(1400)} = 0.09$

8) TIME OF CONCENTRATION:

A) BY KIRPICH'S EQUATION,

$$t_c = [(11.9 \times L^3)/(H_1 - H_2)]^{0.385} = [(11.9 * 0.27^3)/(650 - 513.9)]^{0.385} = 0.09 \text{ hr.}$$

B) BY VELOCITY ESTIMATE,

SLOPE = 9% $\Longrightarrow$ AVG. VELOCITY = 5 ft/sec.

$$t_c = L/V = \frac{1400'}{(5 \text{ ft/sec})(3600 \text{ sec/hr.})} = 0.08 \text{ hr.}$$

USE $t_c = 0.09$ hr.

9) LAG TIME, $t_\ell = 0.6\, t_c = 0.05$ hr.

10) UNIT DURATION, $D \le t_\ell/3 = 0.02$ hr. < 0.083 hr.

USE $D = 0.083$ hr

11) TIME TO PEAK, $T_p = D/2 + t_\ell = 0.04 + 0.05 = 0.09$ hr.

12) PEAK DISCHARGE,

$$q_p = (484 \times A)/T_p = \frac{(484 \times 0.04 \text{ mi}^2)}{0.09} = 215 \text{ cfs}$$

ECI-4 PRC ENGINEERING CONSULTANTS, INC.

Missouri Dam Safety — SHEET NO. ____ OF ____

Railroad Embankment — JOB NO 1253

Reservoir Elevation: Surface Area data — BY TP — DATE 4 18 ?

Elevation (ft, MSL)	Surface Area (acres)	REMARKS
513.9	0.	Invert of culvert
520.0	0.5	Interpolated
530.0	1.5	Interpolated
540.0	3.0	Measured from Vineland, MO 7.5' series Quad
550.0	5.0	Interpolated
560.5	8.0	Top of Embankment
570.0	11.0	Interpolated
580.0	13.0	Measured from Vineland, MO 7.5' series Quad

Missouri Dam Safety Inspection
Combined Pools of Railroad Embankment and Lembeck Lake 1283
Reservoir Elevation - Surface Area Data JFK 4/13/81

Elevation (ft, MSL)	Surface Area (acres)	Remarks
513.9[1]	0	Invert of R.R. Embankment Culvert
520[1]	0.5	Interpolated
530[1]	1.5	Interpolated
540[1]	3.0	Measured from Vineland 7.5' Quad
544.9[2]	15.5	Interpolated
550[2]	30.0	Interpolated
560.5[2]	44.5	Top of R.R. Embankment
570[2]	67.0	Interpolated
580[2]	96.0	Measured from Vineland 7.5' Quad

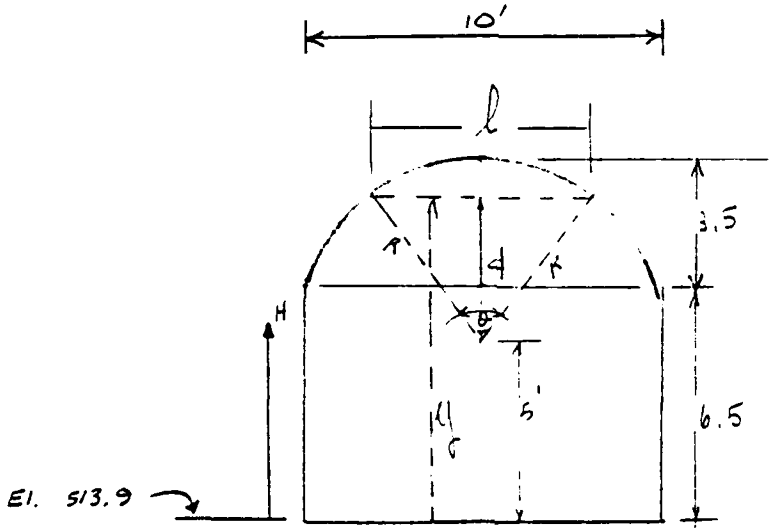
1 - area between R.R. Embankment and Lembeck Lake Dam

2 - combined areas of R.R. Embankment and Lembeck Lake

ECI-4 PRC ENGINEERING CONSULTANTS, INC.

Missouri Dam Safety
Railroad Embankment
Masonry Arch Culvert rating curve

SHEET NO ___ OF ___
JOB NO 1283
BY R DATE 4/8/81



$0 \le H \le 9.75'$ $Q = \frac{2}{3} C_B B H \sqrt{\frac{2}{3} g H}$, $y = \frac{2}{3} H$, $C_B = 1.0$

$9.75 < H \le 15'$

$$\theta = 2 \cos^{-1}\left(\frac{d}{R}\right)$$

$$d = \tfrac{2}{3} H - 5' \quad , R = 5'$$

Segment Area @ any H:

$$A_{s(H)} = A_{segment} = \frac{1}{2} R^2 (\theta - \sin\theta) \quad , \theta = \text{in radians}$$

$$l = 2R \sin\left(\frac{\theta}{2}\right)$$

$$A_{(H=9.75)} = \left(\frac{10 + l_{(H=9.75)}}{2}\right)\left(\frac{2}{3}\right)(9.75) = 63.5$$

Total Area at any H for $9.75' < H \le 15'$

$$A_{(H)} = A_{(H=9.75)} + \left[A_{s(H=9.75)} - A_{s(H)}\right] = 88.0 - A_{s(H)}$$

$$V = \sqrt{g \frac{A}{T}} \quad , Q = C_d V A \quad C_d = 0.9 \quad , T = l_{(H)}$$

$H > 15'$

$$Q = CA\sqrt{2g(H-5)} \quad , C = 0.6$$

$$A = \left(\frac{2}{3}\right)(9.75)\left(\frac{10 + l_{(H=9.75)}}{2}\right) + A_{s(H=9.75)}$$

$$l_{(H=9.75)} = 2R\sin\left(\frac{\theta}{2}\right) \qquad \theta = 2\cos^{-1}\left(\frac{1.5}{5}\right) = 145.08^\circ = 2.53 \text{ radians}$$

$$A_{s(H=9.75)} = \frac{1}{2}R^2(\theta - \sin\theta) = \frac{1}{2}(5)^2\left(2.53 - \sin\left(145.08\right)\right) = 24.5 \text{ ft}^2$$

$$A = \left(\frac{2}{3}\right)(9.75)\left(\frac{10 + (2)(5)\left(\sin\left(\frac{145.08}{2}\right)\right)}{2}\right) + 24.5$$

$$A = 63.5 + 24.5 = 88.0$$

$$\therefore Q = 0.6\,(88.0)\sqrt{2g(H-5)} = 423.7\sqrt{H-5}$$

PRC ENGINEERING CONSULTANTS, INC.

Missouri Dam Safety — SHEET NO. ____ OF ____

Railroad Embankment — JOB NO. 283

Masonry Arch culvert rating curve — BY TV — DATE 4/2/81

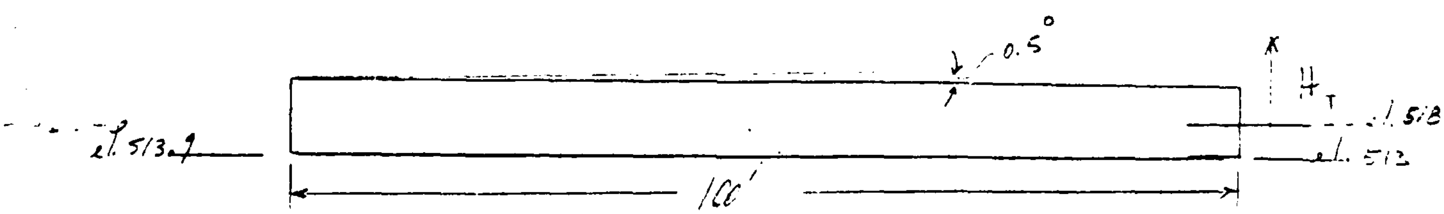
INLET CONTROL CONDITION

WSEL	H	Q
513.9	0	0
515.0	1.1	35.6
520.0	6.1	465.5
525.0	11.1	1049.0
530.0	16.1	1412.
535.0	21.1	1700.
540.0	26.1	1946.
545.0	31.1	2165
550.0	36.1	2363
555.0	41.1	2546
560.0	46.1	2716
561.0	47.1	2749
562	48.1	2782
563	49.1	2814
564	50.1	2845
565	51.1	2877

WSEL	H	Q
516.0	2.1	94.0
517.0	3.1	168.5
518.0	4.1	256.4
519.0	5.1	355.8

Outlet control:

$V = \sqrt{\frac{2gH_T}{\Sigma K}}$, $Q = VA$, $A = 88.0$ sq. ft.



$K_{ent} = 0.5$

$K_{exit} = 1$

$K_f = \frac{29.16\, n^2 l}{R^{4/3}}$

$n = 0.025$

$l = 100$

$R = \frac{A}{P} = \frac{88}{15.71 + 6.5(2) + 10} = 2.27'$

PRC ENGINEERING CONSULTANTS, INC.

Missouri Dam Safety | SHEET NO ___ OF ___
Railroad Embankment | JOB NO 1283
Mummy Arch culvert rating curve | BY TT DATE 4/8/81

$$K_f = \frac{(29.16)(0.025)^2(100')}{(2.27)^{1.33}} = 0.61$$

$$\Sigma K = 1.0 + 0.5 + 0.61 = 2.1$$

$$Q = 88\sqrt{\frac{2g H_T}{2.1}} = 487.3\sqrt{H_T}$$

$$H_T = WSEL - 518$$

WSEL	H	Q
530.0	12.0	1688
535.0	17.0	2009
540.	22.0	2286
545.	27.0	2532
550	32.0	2757
555	37.0	2964
560	42.0	3158
561	43.0	3195
562	44.0	3232
563	45.0	3269
564	46.0	3305
565	47.0	3341

INLET WILL ALWAYS CONTROL

Check critical depth assumption:

② $H = 6.1$, $y_c = 2/3 H = 4.07$

$S = 0.0087$

$n = 0.025$

$A = (4.07)(10') = 40.7 \text{ ft}^2$

$R = \frac{A}{P}$, $P = (4.07)(2) + 10' = 18.13'$

$R = \frac{40.7}{18.3} = 2.24'$

$Q_n = \frac{1.49}{0.025}(40.7)(18.13)^{2/3}(0.0087)^{1/2} = 1561.5 \text{ cfs}$

$Q_c = 465.5$

Since $Q_n > Q_c$

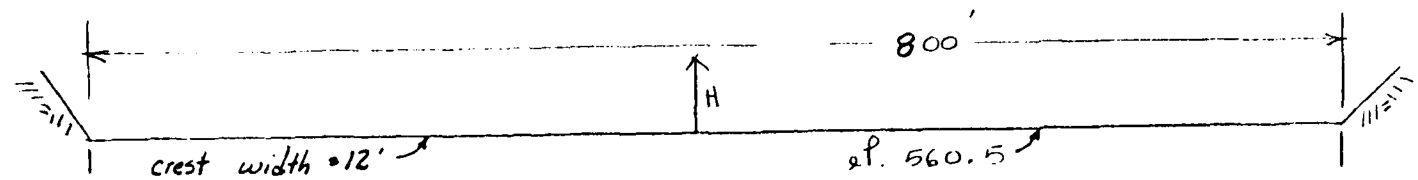
critical depth assumption is Ok.

PRC ENGINEERING CONSULTANTS, INC.

Missouri Dam Safety — SHEET NO ___ OF ___

Railroad Embankment — JOB NO. 1281

Overtop rating curve — BY TP DATE 4/8/8



for any H $Q = cLH^{3/2}$, $L = 800'$

$H = WSEL - 560.5$

WSEL	H	C	Q
513.9			
515.0			
520.0			
525.0			
530.0			
535.0			
540.0			
545.0			
550.0			
555.0			
560.0	0	0	
561	0.5	3.01	851
562	1.5	3.04	4468
563	2.5	3.07	9708
564	3.5	3.09	16168
565	4.5	3.09	23598

PRC ENGINEERING CONSULTANTS, INC.

Missouri Dam Safety SHEET NO. ____ OF ____

Railroad Embankment JOB NO. 1283

Combined Rating curve BY TP DATE 4/9/8

Combined Rating Curve

WSEL	$Q_{CULVERT}$	$Q_{OVERTOP}$	Q_{TOTAL}
513.9	0		0
515.0	36		36
516.0	94		94
517.0	169		169
518.0	256		256
519.0	356		356
520.0	466		466
525.0	1049		1049
530.0	1412		1412
535.0	1700		1700
540.0	1946		1946
545.0	2165		2165
550.0	2363		2363
555.0	2546		2546
560.0	2716	0	2716
561.0	2749	851	3600
562.0	2782	4468	7250
563.0	2814	9708	12522
564.0	2845	16168	19013
565.0	2877	23598	26475

SUMMARY OF PMF AND ONE-HALF PMF ROUTING

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**********************************
FLOOD HYDROGRAPH PACKAGE (HEC-1)
DAM SAFETY VERSION       JULY 1978
  LAST MODIFICATION  01 APR 80
**********************************
A1                  MISSOURI DAM SAFETY
A2                 LEMBECK LAKE DAM
A3                PMF AND 50 PERCENT PMF
B     300       0       5       0       0       0       0       0       0       0
B1      5
J       1       2       1
J1      1      .5
K        DA LEMB                                    1
K1       RUNOFF CALCULATION FOR LEMBECK LAKE DRAINAGE AREA
M       1       2    3.44            3.44       1                       1
P            25.7     100     120     130
T                                                  -1     -87
W2            .67
X                       1
K       1RAIL DM                                    1
K1       ROUTE HYDROGRAPH THROUGH RAIL EMBANKMENT
Y                               1       1
Y1      1                                      -513.9      -1
Y4  513.9     515     516     517     518     519     520     525     530     535
Y4    540     545     550     555     560     561     562     563     564     565
Y5      0      36      94     169     256     356     466    1049    1412    1700
Y5   1946    2165    2363    2546    2716    3600    7250   12522   19013   26475
$A      0      .5     1.5       3    15.5      30    44.5      67      96
$E  513.9     520     530     540   544.9     550   560.5     570     580
$$  513.9
$D  560.5
K      99
```

SUMMARY OF DAM SAFETY ANALYSIS

1 ....

	INITIAL VALUE	SPILLWAY CREST	TOP OF DAM
ELEVATION	513.90	513.90	560.50
STORAGE	0.	0.	577.
OUTFLOW	0.	0.	3158.

RATIO OF PMF	MAXIMUM RESERVOIR W.S.ELEV	MAXIMUM DEPTH OVER DAM	MAXIMUM STORAGE AC-FT	MAXIMUM OUTFLOW CFS	DURATION OVER TOP HOURS	TIME OF MAX OUTFLOW HOURS	TIME OF FAILURE HOURS
1.00	564.28	3.78	761.	21111.	4.50	16.33	0.00
.50	562.29	1.79	660.	8778.	2.33	16.58	0.00

PERCENT OF PMF ROUTING
EQUAL TO SPILLWAY CAPACITY

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*************************
DROGRAPH PACKAGE (HEC-1)
TY VERSION     JULY 1978
ODIFICATION  01 APR 80
*************************
            A1                  MISSOURI DAM SAFETY
            A2                 LEMBECK LAKE DAM
            A3                 PERCENT PMF
            B     300       0       5       0       0       0       0       0       0       0
            B1      5
            J       1       3       1
            J1    .12     .13     .14
            K       DA LEMB                                     1
            K1      RUNOFF CALCULATION FOR LEMBECK LAKE DRAINAGE AREA
            M       1       2     3.4             3.4       1                       1
            P            25.7     100     120     130
            T                                                  -1     -87
            W2            .67
            X                       1
            K      1LEMB DM                                     1
            K1      ROUTE HYDROGRAPH THROUGH LEMBECK LAKE DAM
            Y                               1       1
            Y1      1                                      -544.9      -1
            Y4  544.9   545.4   546.0   546.5   547.0   547.8   548.7   549.5   550.6   551.4
            Y4  552.2   553.3   554.2   555.1   555.9
            Y5      0      20     107     245     429     829    1350    1978    3132    5113
            Y5   8377   14122   19806   25806   32394
            $A      0       3       9    11.5      25    35.5      56      83
            $E    520     530     540   544.9     550     560     570     580
            $$  544.9
            $D    550
```

```
K       DA RAIL                                                      1
K1      RUNOFF CALCULATION FOR RAIL EMBANKMENT DRAINAGE AREA
M      1       2     .04             .04       1                             1
P          25.7     100     120      130
T                                                            -1     -87
W2          .05
X                   1
K       2U/S RLW                                                     1
K1       COMBINE LEMBECK LAKE AND RAIL EMBANKMENT DRAINAGE RUNOFF
K       1RAIL DM                                                     1
K1       ROUTE HYDROGRAPH THROUGH RAIL EMBANKMENT
Y                                    1       1
Y1         1                                                -513.9      -1
Y4  513.9     515     516     517     518     519     520     525     530     535
Y4    540     545     550     555     560     561     562     563     564     565
Y5      0      36      94     169     256     356     466    1049    1412    1700
Y5   1946    2165    2363    2546    2716    3600    7250   12522   19013   26475
$A      0      .5     1.5       3       5       8      11      13
$E  513.9     520     530     540     550   560.5     570     580
$$  513.9
$D  560.5
K      99
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SUMMARY OF DAM SAFETY ANALYSIS

N 1 ....

	INITIAL VALUE	SPILLWAY CREST	TOP OF DAM
ELEVATION	544.90	544.90	550.00
STORAGE	117.	117.	208.
OUTFLOW	0.	0.	2503.

RATIO OF PMF	MAXIMUM RESERVOIR W.S.ELEV	MAXIMUM DEPTH OVER DAM	MAXIMUM STORAGE AC-FT	MAXIMUM OUTFLOW CFS	DURATION OVER TOP HOURS	TIME OF MAX OUTFLOW HOURS	TIME OF FAILURE HOURS
.12	549.74	0.00	202.	2229.	0.00	16.50	0.00
.13	549.93	0.00	207.	2430.	0.00	16.50	0.00
.14	550.12	.12	211.	2627.	.42	16.50	0.00

SUMMARY OF DAM SAFETY ANALYSIS

1 ....

	INITIAL VALUE	SPILLWAY CREST	TOP OF DAM
ELEVATION	513.90	513.90	560.50
STORAGE	0.	0.	140.
OUTFLOW	0.	0.	3158.

RATIO OF PMF	MAXIMUM RESERVOIR W.S.ELEV	MAXIMUM DEPTH OVER DAM	MAXIMUM STORAGE AC-FT	MAXIMUM OUTFLOW CFS	DURATION OVER TOP HOURS	TIME OF MAX OUTFLOW HOURS	TIME OF FAILURE HOURS
.12	539.54	0.00	31.	1923.	0.00	16.83	0.00
.13	542.04	0.00	39.	2035.	0.00	16.92	0.00
.14	544.49	0.00	48.	2143.	0.00	16.92	0.00

END

DATE
FILMED

10-81

DTIC